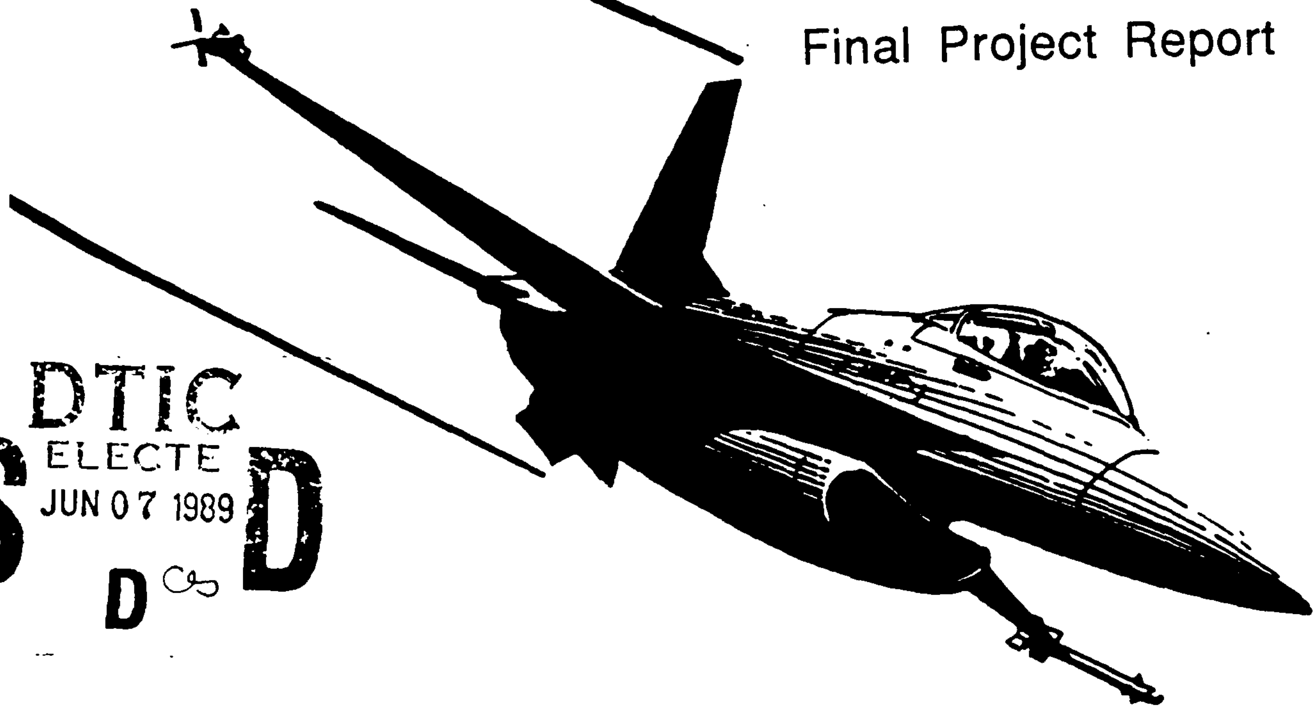
GENERAL DYNAMICS
FORT WORTH DIVISION

INDUSTRIAL TECHNOLOGY MODERNIZATION PROGRAM

Phase 2
Final Project Report



PROJECT 44

MODERNIZE FACILITY EQUIPMENT AND PROCESSES

VOLUME 1 REVISION 2

Honeywell
Military Avionics Division

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The fabrication task will be divided between four functional departments 1) metal finishing, 2) flexible machining, 3) tool model/short runshop and 4) dedicated machining. Each area will handle a special work task either supporting other fabrication activities or reacting to special volume/set up needs. Order schedules will be handled by the MAP system, critical resources management is directed by the CRP module and timely procurement of material is the responsibility of the PMC (Purchase Material) Module. Some reserve capacity is maintained to handle "must have jobs". Metal finish will support all other slip with coating and finish processing, while flexible machining will handle moderate/high volume parts that do not pass machine utilization thresholds. The tool model/short run slip will handle low volume/high set up needs and provide back up to the flexible shops. High volume precision parts will process across the dedicated machining cell.

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GENERAL DYNAMICS
FORT WORTH DIVISION

INDUSTRIAL TECHNOLOGY MODERNIZATION PROGRAM

PROJECT 44

PHASE 2 FINAL PROJECT REPORT

MODERNIZE FACILITY EQUIPMENT AND PROCESSES

VOLUME 1 REVISION 2

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INTRODUCTION

FINAL REPORTS FOR ITM PROJECT 44

MODERNIZE FACILITY EQUIPMENT AND PROCESSES

In accordance with PO #1005262, Military Avionics Division of Honeywell herein submits to General Dynamics the Final Project Report and Final Cost Benefit Analysis Report for ITM Project 44.

The reports are contained in four (4) volumes.

- Volumes One and Two contain the Final Project Report for the project.
- Volume Three was a Supplement which was incorporated into Volumes One and Two during Revision 2.
- Volumes Four and Five contain the Final Cost Benefit Analysis Report.

The Tables of Contents and a Lists of Illustrations are organized as follows:

- For the Final Project Report, they are at the beginning of Volume One.
- For the Final Cost Benefit Analysis Report, they are at the beginning of Volume Four.

Project 44 was divided and examined as nine (9) separate Work Cells plus an Overview. The order in which the cells are presented has been standardized in each of the reports and supplement based on implementation dates (with the exception of NC Programming which is implemented concurrent with the implementation of each individual cell). The order of presentation of the cells is as follows:

1. Project Overview
2. Laser Base Cell
3. Walnut Cell
4. Sheetmetal Cell
5. Pallet Cell
6. Lamination Cell
7. Girth Ring Cell
8. Model/Short Run Shop and Flexible Machining Area
   included are the Dither Spring Cell and 1 1/2" Bar Cell
9. NC Programming
10. T-Bar Cell

PROJECT 44

MODERNIZE FACILITY EQUIPMENT AND PROCESSES

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PROJECT 44

MODERNIZE FACILITY EQUIPMENT AND PROCESSES

PROJECT OVERVIEW

SECTION 1

INTRODUCTION

The Fabrication Facility (Fab Fac) business area is located in Honeywell's Stinson/Ridgway facility. Fab Fac is part of the Inertial Instruments Operations (IIO) within Honeywell's Military Avionics Division (MAvD). Fab Fac performs machining, fabricating and model/tool making tasks for MAvD business groups and Commercial Avionics Division (CAvD) on a regular basis. Similar tasks are performed for any requesting Honeywell business group on an exception basis. Fab Fac is not a profit center. All work performed is cost transferred to the internal customer at actual labor expended. The mix of work ranges from high volume precision gyroscope parts, to a high variety mix of moderate volume parts to one of a kind models, tools and unexpected spares orders.

The implementation of Project 44 will convert the Fabrication Facility into a modern manufacturing shop. High volume work will be performed in dedicated work cells. Moderate volume work will be completed in a single area with flexible machining lines. Low volume, spares, tools and models will be completed in a Short Run/Model Shop. Each of these three primary areas will have complete accountability for the cost, quality and timely delivery of products that are processed in their area.

Modernization of the equipment, together with the segmentation of the organizational structure to focus on specific area performance, will reduce product costs without compromise to product quality. Direct labor costs will be reduced substantially. Delivery times will be shortened dramatically and will be accurately predictable. Increased responsiveness to Honeywell internal business groups will assist them in meeting their customer needs and increasing volumes through increased business with those customers.

It is anticipated that Project 44 will be implemented in work cell segments. Those engineers that completed the study and reports for the various segments will become "sponsors" during implementation and will have a major role in implementation. By installing the project in parts, it will meet practical requirements for capital appropriation and allow implementation with existing engineering resources.

The Project 44 Final Report is also segmented. The segments are linked by and summarized in this Project Overview. This approach was used to reduce the project complexity by breaking it into more easily digestible components. Supporting information is either replicated or referenced in each cell listed below.

- WALNUT CELL
- LASER CELL
- GIRTH RING CELL
- PALLET CELL
- LAMINATION CELL
- NC PROGRAMMING SUPPORT SYSTEMS
- SHEETMETAL CELL
- MODEL SHOP/SHORT RUN SHOP/FLEX CELL
- T-BAR CELL

SECTION 2

PROJECT PURPOSE/OVERVIEW

Project 44 will rescope the entire Fabrication Facility production department and Tool Room/Model Shop. It will radically change the processes, equipment, scheduling methods and part costs. The facility will become more responsive to each of the Honeywell business groups it serves.

Key changes when the project is implemented through Phase 3 will include:

- Dedicated Work Cells - will replace sequential operations that travel through many departments for parts or part families with high annual hours of shop load. Costs, lead times and work-in-process for these high volume part families will decrease substantially.

- Flexible Machining Areas - for repeat parts with moderate volume, current single discipline departments will be replaced by a focussed Turning, Grinding and a Milling Drilling area. The responsibility for a part's quality, cost and schedule will be the responsibility of one department.

- Tool Room/Model/Short Run Shop-equipped with the latest technology in CNC equipment and tape prepartion, models and tools. Short run parts will be produced expeditiously with competitive overall costs.

The Phase 3 implementation has high financial return with relatively low risk. Accomplishment of the key changes will occur by combining current proven technologies, standard capital equipment, standardized controllers and computer systems into packages suitable for each of our applications.

SECTION 3

TECHNICAL APPROACH

The primary purpose of Project 44 was the investigation and justification of technologies, equipment and systems integrations that will meet the Fabrication mission of cost, quality, dependability and flexibility.

The Phase 2 development study expanded and analyzed the cost reducing concepts of the Phase 1 report. It followed the specific requirements of the Phase 2 proposal Statement of Work. The study dropped concepts that were found to be uneconomical and explored potentially profitable new concepts as identified by the Phase 2 investigation.

CORE TEAM FORMATION

A core engineering team was formed to prepare the base data for more detailed investigation by additional engineers with specific part knowledge or process expertise. The team consisted of a Project Manager (Fab Fac Lead Production Engineer), one internal (Fab Fac Production Engineer) and one contract engineer. A conference room was converted into a project office, clerical services established, and services of all Fab Fac P.E.'s made available on an as required basis. To free time for Fab Fac engineers to participate, re-hired retirees were contracted periodically during the project. This approach, combined with the expertise of a contract consulting engineer resulted in project synergism.

FORMATION OF INVESTIGATIVE PARTS BASE

The Phase 1 study produced workbooks that identified high hour usage parts for a three month release of orders. This list was further refined to include all parts run in a 12 month period with 30 or more total actual hours of combined run, set up, rework and salvage. The list was computer sorted to arrange parts in order of annual hourly input. Those parts that comprised 80% of the 30 hour close out volume were further segregated by device (end use). This established the starting point for the investigation of production parts.

All parts subcontracted between January 1, and September 1, of 1986 were compiled, together with their actual total vender cost. Each order cost total was divided by the cost of a Fab Fac hour at originating burden to yield "equivalent" hours. All subcontract parts with equivalent hours of 30 or more were added to the investigative parts list.

Project 51/52 had compiled a parts list by final device as part of their investigation. Project 44 compared the fabricated and purchased parts of this list with the previous lists developed in Fab. All subcontracted or fabricated parts from high volume or potential high volume Project 51/52 final devices were compared to the Fab lists and added if not already present.

When fabricated parts are subcontracted for capacity or costs they are reviewed by a joint management/union committee. The actions of this committee are summarized on a weekly listing. A two year history of these records was reviewed to locate large or multi year subcontract purchases. These parts were added to the investigative list.

ANALYSIS OF PARTS BASE

A spread sheet of part number by annual run and set up hours per key manufacturing resource was prepared. Final device, business group, forecast volume and a comment section were added to the matrix. Those parts without an existing internal manufacturing process were estimated per the Fab Fac make/buy procedure. The final matrix was approximately 350 parts long by 40 critical manufacturing resource (work centers) wide.

The matrix was first sorted by final product device. Those parts with common process paths were analyzed for work cell potential. The matrix was again sorted by business group, the patterns analyzed and work cell potential parts summarized. Since initial funding for a potential Phase 3 implementation would either be provided by or strongly supported by the individual Honeywell business groups, this approach was deemed most practical.

The complete matrix was then sorted by critical manufacturing resources (work centers). The results were analyzed and potential work cell parts groupings summarized.

The part groups from the three sorts were analyzed and preliminary concepts/designs for work cells developed. Those parts deemed to merit in depth analysis for work cell formation were removed from the matrix.

The existing matrix, with cell potential parts removed, was again sorted by critical manufacturing resource (work center). The totals hours/year by resource were analyzed to determine process flow paths for a flexible machining area concept (Flex Shop). The parts with similar process flow characteristics were removed from the matrix for analysis of a creation of a Flex Shop to process moderate volume parts. The remaining parts on the list were left for consideration in either the Flex Shop or possibly to be considered for the Tool Room/Model Shop area.

A Tool Room/Model Shop/Short Run Shop Area concept was proposed to construct tools, models and short run jobs. Short run jobs were defined as those where actual set up time would equal or exceed run time in the "As-Is" shop.

To support the changeover of currently fabricated or subcontracted parts to dedicated work cells, and centers, considerable machine tool programming would be required. To evaluate this perceived need, a NC Programming System evaluation was added to the investigative assignments.

At the time of completion of Phase 1, Fab Fac management made a decision as equipment becomes obsolete or not economically repairable, to withdraw from fabrication of sheetmetal parts. During the Phase 2 study, Fab Fac received a large increase in sheetmetal part orders from the Test Systems and Logistics Operations (TSLO). Business projections for TSLO indicated the increased sheetmetal load would probably continue. A study was initiated and suggested that it may be a better decision to upgrade the Fab Fac sheetmetal equipment, rather than abandon that manufacturing area. The interaction of these events resulted in a decision to add a Sheetmetal Processing Cell/Flex area to the Phase 2 investigation.

The method described above to analyze the effective shop parts manufacturing requirements made effective use of engineering resources. Since the tasks were tiered, technologies or parts analyzed and found unsuitable for work cell/center flowed to the next level for consideration. This continued until there was a full distribution of the list of identified parts from dedicated work cells to low volume parts processed in the model shop.

PROJECT SEGMENT INVESTIGATIONS

The analysis of the parts base suggested a list of parts to be considered for dedicated work cells. Part or work center groupings were identified that could have significant cost/delivery improvement in a flexible machining area. Ideas for improvements to the Tool Room/Model Shop were proposed. A need for a cost effective NC Programming Support System was also indicated to support the proposed changeovers in manufacturing methods. The following project segments were established:

- WALNUT CELL - The "Walnut" is a series of match machined gimbal assemblies for the GNAT series gyroscopes. This cell proposes to condense the manufacture of six piece parts and forty-four operations into an integrated area.

- T-BAR CELL - The "T" (Torsion) Bar is a series of miniature parts that mechanically transmit motion rates to output devices within the GNAT series gyroscopes. The cell proposes to consolidate turning, grinding, drilling, testing and feedback from testing to grinding.

- LAMINATION CELL - Laminations are bonded and machined gyroscope rotors, stators and peripheral devices. The cell proposes to consolidate the manufacturing, or responsibility, into a single area.

- GIRTH RING CELL - The "Girth Ring" cell is the GG1111 iron gyroscope counterpart of the Walnut Cell described earlier. It proposes to combine turning, milling, drilling, grinding, laser welding, impregnation and metal finish into a single area.

- 1 1/2" BAR CELL - The 1 1/2" Bar Cell is a turning cell that would accommodate parts of a maximum of 1 1/2" diameter. The proposed (primary) lathe in the cell would be a double (front and rear) chucked machine with live tooling. Part volumes from the GG1111 gyroscopes, GNAT gyroscopes, Helmet Sights (IHADDS) and Flight System Operations (FSO) suggest requirements for two or more primary machines.

- PALLET CELL - The "Pallet" cell (palletized horizontal machining centers) proposed to accommodate parts that would fit a 10 inch cube. Palletized loading, tool storage and retrieval and fixturing would be accomplished on a horizontal pallet machining center. Part volumes from the IIO, FSO and CAvD indicated two or more linked cells would be required.

- SHEETMETAL CELL - The cell proposed to complete NC punch press and related support operations for TSLO test station panel work.

- DITHER SPRING CELL - The "Dither Spring" is a key-controlled component in the laser gyroscope. The cell proposes to combine turning, drilling, grinding, milling, wire Electrical Discharge Machining (EDM) and bench operations into a compact, integrated area.

- LASER BASE CELL - The "Laser Base" is the metal mounting base for the laser gyroscope. The proposed design would combine milling, drilling, lapping, metal finish and helicoil insertion for the laser base and associated components.

- NC PROGRAMMING SUPPORT SYSTEM - To support conversion of parts moved to cells or the low volume work moved to the Model Shop, an NC support system is required. The desired system should integrate with the Honeywell Computervision design base.

- MODEL SHOP - This project proposed to investigate the machines, area, work environment and systems required to cost effectively process unique models or batches of parts while still supporting customer schedule requirements. Additionally, to design a cost effective responsive system to produce batches of production parts where the normal manufacturing set up time exceeds the run time.

- FLEXIBLE MACHINING AREA - This segment proposed to design a flexible machining area to process moderate volume parts. The area will be responsible for the cost, quality and delivery of parts.

Investigative teams were formed for each of the project segments listed above. A team captain, and clear cut lines of authority, responsibility, and accountability were formalized for each team. Weekly meetings were held with the Project Manager and the P.E. Department Supervisor to review schedules, costs incurred, status, compliance with the project statement of work, and air problems for resolution. The weekly meeting was followed with a meeting of top level Fab Fac managers, IIO Project Leader, Project 44 Project Leader and MAvD Tech Mod program office. Problems were aired and resolved or action taken to seek resolution in an expedient manner. This method maintained control of progress, costs and schedule well within permissible limits.

The segment investigations were conducted by members of the Fab Fac Production Engineering department according to their knowledge of piece part (final use) tolerance and process constraints, expertise in computer integration and technology search. A ground rule for engineering participation was a willingness to commit not only to complete the study, but to also "sponsor" the segment and commit to participate fully in installation of the final design. When project work had progressed to the point of selecting final designs, there was direct involvement of the factory supervisor and operators in the affected departments.

Meetings with the Teamsters Local 1145 top officers and Honeywell general office labor relations representatives were held. The concept of work cells, proposed changes in manufacturing distribution, long term benefits and short term disruptions were discussed. All information and any requested back up detail in the quarterly project reports was fully disclosed. At the concurrence of the meetings, meetings were held with all hourly Fab Fac employees. A general presentation of the objectives of the project and the specific project segment concepts were fully disclosed.

Team representatives were invited to participate in vendor visits and sales presentations of equipment under consideration. These team liaisons, together with an open door policy in the Fab project office encouraged a sense of involvement among the hourly employees.

PROJECT SEGMENT FINDINGS

The following are the result of the investigations completed by the project segment teams:

- The T-Bar Cell was not completed. Due to a drop in market forecast and a rise in the relative cost of the Swiss Franc, the project failed to meet minimum financial return and utilization hurdles. Parts that were used to fill capacity in the CNC swiss style lathe were merged with the 1 1/2" Bar Cell project segment. If volume or exchange rates improve, the cell will be reviewed for internal resumption of the investigation.

- The 1 1/2" Bar Cell was merged with the Flexible Machining Segment. The part volumes and process varieties would not support an independent cell.

- The "Dither Spring Cell" was merged with the Flexible Machining Segment. Machine utilization would not support a stand alone cell.

- The "Laser Base Cell" will effectively become part of the Pallet Cell. Since the Laser Cell was used to model many of the cell concepts used in other project segments, it was written as if it stood alone.

- The "Sheetmetal Cell" will effectively become part of the Model Shop/Short Run Shop/Flex Cell area. Since the work performed is unique among the Fab processes, it was written as if it were a stand alone segment.

- The "Model Shop" was merged with the "Flexible Machining Area" to form the "Model Shop/Short Run Shop/Flex Cell". Administratively there will still be a division in the work force for each area. There is also a difference in union work groups and labor grades for each group. Since the two areas will share machinery, they are best described within one report segment.

CONCLUSION OF TECHNICAL APPROACH

The conclusion to the technical approaches used in each project segment are contained in the technical approach section of the final reports labeled:

- WALNUT CELL
- MODEL SHOP/SHORT RUN SHOP/FLEX CELL
- T-BAR CELL
- LASER CELL
- GIRTH RING CELL
- PALLET CELL
- LAMINATION CELL
- NC PROGRAMMING SUPPORT SYSTEMS
- SHEETMETAL CELL

CONCLUSION OF OVERALL TECHNICAL APPROACH

As the final designs for the project segments were prepared, they were drawn to scale on computers. The individual areas were then manipulated for space utilization by both manual and computer techniques. The individual designs were constructed with the supporting beam grid work included as the area base. This allowed greater flexibility in positioning cells in various trial locations on the plant wide document. It also allowed each segment area to be enlarged by computer for discussion and review by supervisors, hourly teams and concerned individuals.

Issues of overall building occupancy areas and efficient in plant interaction by business groups and Tech Mod Projects 20, 51, 52, 43, and 44 were resolved by senior management. Two weekly meetings with Fab Fac senior staff and the segment team captains were held to raise and resolve inter project, business group and project segment area layouts. Specific actions were taken by all team areas to resolve the overall shop layout issues.

As Final Reports were completed by each segment team, they were checked for accuracy and compliance with the SOW by Fab, IIO and MAvD Tech Mod project leaders and staff.

SECTION 4

"AS-IS" PROCESS

The Fabrication Facility (Fab Fac) is located on the first floor of Honeywell's Stinson/Ridgway and the second floor of the St. Louis Park facilities. These facilities manufacture/supply approximately 70% of the mechanical components and some of the tooling and models used by other Honeywell Avionics departments in Minneapolis. These departments include, Microwave Systems Production (MSP), Test Systems Production (TSP), Target Systems (TS), Precision Control Instruments (PCI) and Flight Management Systems (FM).

The Fabrication Facility operation is comprised of four functional areas - Production Control, Production Engineering, Quality Assurance, and Fabrication Facility (Fab Fac Manufacturing). The plant layout is shown on Figure 4.1. Fab Fac has a typical job shop environment with many small lot sizes and a multitude of different part structures. More than 500 orders are processed every month, with an average of approximately 200 parts per order. There is a total of approximately 1800 different part groups produced in Fab Fac. Of these, 135 part groups make up 80% of the total annual quantity delivered. Very little dedicated equipment is used, resulting in significant set-up costs. This results in many general-purpose machining operations on a variety of materials ranging from mild steel, aluminum, nickel, iron, brass, magnesium, invar and stainless steel. These parts are often machined to tight tolerances of .0001 inches or better.

The Fabrication Facility is divided into five departments with manufacturing at both the Stinson/Ridgway and St. Louis Park plants. Proportionate space allocations are shown on Figure 4.2.

All work orders for Fab Fac are generated through the computer "Factory Order Generation" system (FOG) and distributed through a shop packet, tool make order, or express order. Components are fabricated entirely by one department or move between departments according to detailed process documents and summary sheet instructions.

Material does not follow a simple flow through the shop. Process flows are complex, and orders are routed to the various work stations in order to generate their particular shapes. This is shown in Figure 4.3.

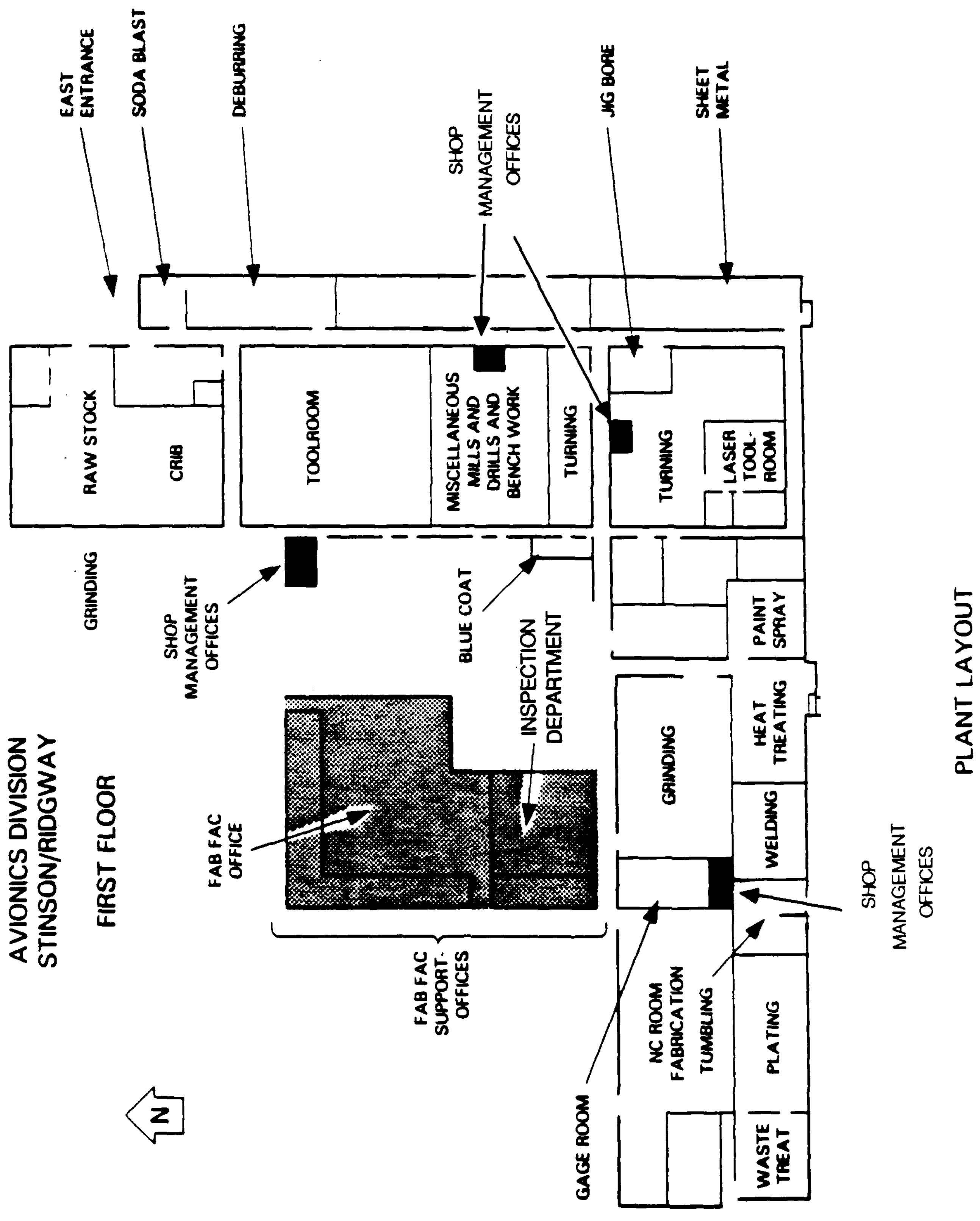
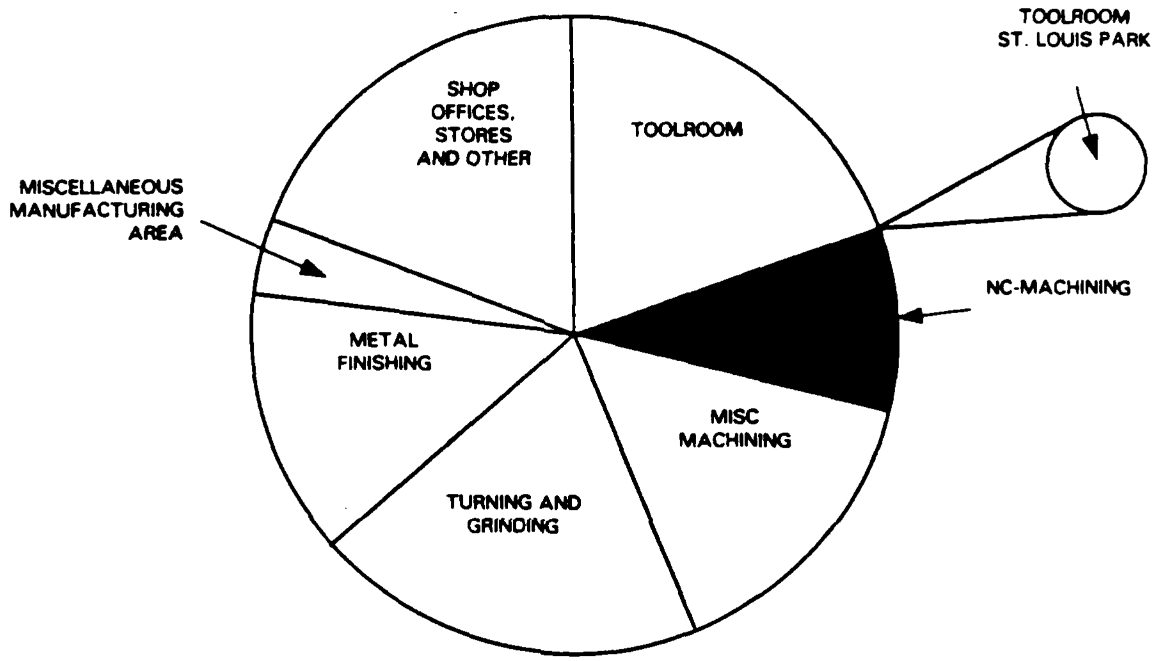


Figure 4.1 "As-Is" Fabrication Facility Layout



NC-MACHINING OCCUPIES THE SMALLEST
PORTION OF THE SHOP AREA SPACE DISTRIBUTION

Figure 4.2 "As-Is" Space Distribution Fabrication Facility

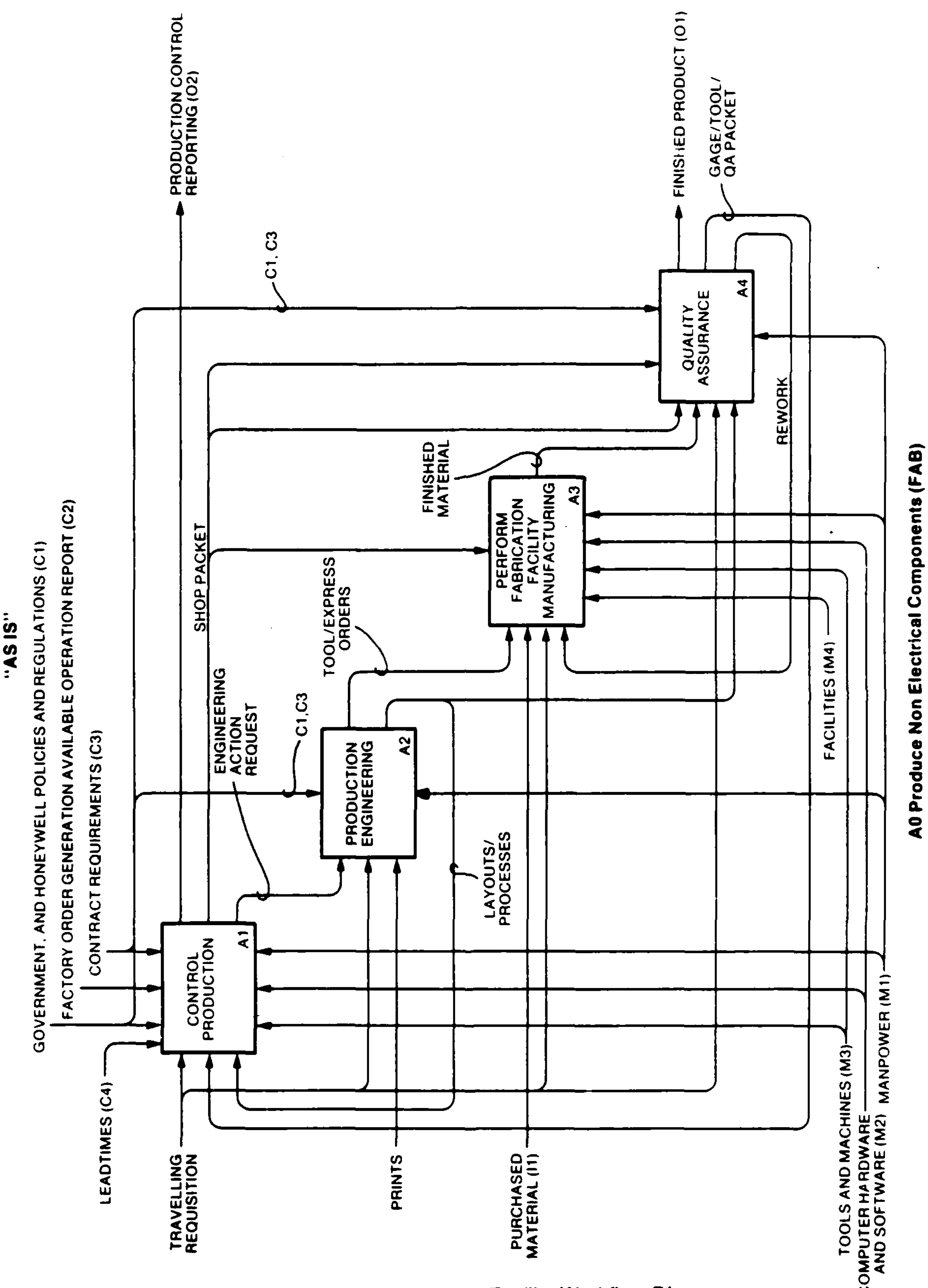


Figure 4.3 "As-Is" Fabrication Facility Workflow Diagram

Process instructions describe the sequential order in which manufacturing has to perform the various tasks of macnining and finishing of components. They also include detailed specifications for required tooling, fixturing, and critical machining data and also select the equipment on which the process is to be performed. For planning and scheduling purposes, alternate equipment is sometimes used. Detail of summary sheets have time standards for each of the process steps or operations based on time elements developed by Industrial Engineering.

Inspection operations are performed at specified process steps as defined by process summary sheets. All components receive final inspection before they are shipped. Tooling and fixtures are returned to designated storage areas after their related operations are completed. Gauges are returned to inspection for calibration. Expendable cutting tools are returned to stores to be sharpened and prepared for the next use. Expendable drills are not returned or reused for manufacturing operations.

All movements of job packets, orders and materials are done manually by hand-carry or hand cart. These moves are performed by stores personnel after the work centers/work stations finalize their operations. When completed, they are placed on shelves conveniently located throughout the manufacturing area for work-in-process and raw material.

One of Fab Fac's functions, the manufacture of tools and models, is performed in dedicated areas of both facilities (Stinson/Ridgway, St. Louis Park). These areas supply Honeywell Avionics departments with tools, fixtures, or models/prototypes related to internal programs.

NC programming is a shared function performed either by Model Shop programmers or Production Engineers. Production Engineers provide technical guidance and review NC programs generated by Model Shop programmers, which are used in Production.

The majority of NC programming is done manually by development of cutter center line paths. Automatically Programmed Tools (APT) based computer assist is available on a time share basis but is little used. Advanced training is a responsibility of the hourly programmer to obtain, not retain, employment. There is significant potential for reduced cost for both conversion of jobs to new equipment and updates to NC tapes caused by design engineering change orders. CNC programming for the tool room and model shop machines are the complete responsibility of the tool room and model shop personnel.

Most of the more than 360 listed machine tools or equipment in the Fab Facility are conventional or manual machines. A small percentage (5%) are numerically controlled. Manual operations are performed at the numerous work benches located throughout the Fab Fac department.

WORK FORCE

The work force levels of the Fab area mirror the order volumes placed by internal customers. The pattern is typical of a captive "job shop". Much of the fluctuation is the result of not having a reliable forecast to do long and short range load leveling of manpower and machine capacities.

COMPUTER APPLICATIONS

Fabrication Facility has both CNC and NC controlled machine tools. Ten CNC machines and two NC machines with before tape reader memory expansions can be connected via RS232 link to DNC. Other NC machines would require various degrees of modification, but all are convertible to DNC.

NC programming is aided by a generic post processing (Micro-Numeric) system equipped with minimal options. The system is used equally for business as well as tape creation of editing. UCCEL (APT) is available on a teletype terminal on a timeshare basis.

Six personal computers (RADIO SHACK TRS-80, Apple and Columbia) are used by Production Supervision and Production Engineers. They use modified generic programs to produce local control reports. Many process layouts (controlled production instructions) are produced, several with graphics.

Since Honeywell MAvD recognized the importance of computer-integrated manufacturing systems prior to the start of Honeywell's Tech Mod program, there are several ongoing MIS projects, each of which provides an essential CIM building block. Existing systems projects include:

- HONEYWELL MANUFACTURING SYSTEM (HMS): A packaged, integrated manufacturing system including inventory record management, manufacturing data control, MRPII, master production scheduling, purchased material control, capacity requirements planning, shop floor control, and statistical order forecasting. This project is being accomplished through close cooperation between Honeywell MAvD and Honeywell Information Systems (HIS) Group which developed the HMS package. HIS is involved in the project to ensure that the special government-related needs of MAvD are satisfied by HMS. A current MAvD pilot program in a user area is being used to test the HMS package and develop the necessary modifications. The result of this close cooperation will be the development of a manufacturing package that will meet the special needs of MAvD and other government contractors.

- PROCESS MANAGEMENT SYSTEM (PMS): A custom-made paperless production engineering tool designed to allow on-line entry and modification of parts lists, detail summaries, layouts, and process detail.

- FACTORY DATA COLLECTION (FDC): A custom-made system designed to automate factory data collection through the use of data entry terminals, bar code readers, and voice data entry systems. It is to be integrated with HMS to increase data collection efficiency.

- COMPUTER AIDED MANUFACTURING AND INTEGRATED DOCUMENTATION (CAMAID): A series of CAD/CAM/CAE projects to automate design and production engineering tasks. It includes plans to integrate and automate the design-to-production transition and provides for direct links to DNC equipment.

SECTION 5

"TO-BE" PROCESS

The Fabrication Facility (Fab Fac) business remains in the Stinson/Ridgway facility. A small tool room remains at the St. Louis Park (SLP) facility. Fab Fac performs machining, fabricating and model/tool making for Honeywell internal customers. Fab Fac is not a profit center. All work performed is cost transferred to the business group served at actual cost expended to produce. The mix of work ranges from high volume, precision gyroscope parts, to a high variety mix of moderate volume parts, to one of a kind models and unexpected spares orders. Fab Fac has been reshaped to meet the customer requirements and their diverse work load input.

The total space requirement will be reduced by approximately 7,200 square feet. Figure 5.1 shows the allocation of Fab Fac in the Stinson/Ridgway Facility and Figure 5.2 of the functional and support areas. Figure 5.3 shows the area reduction at the SLP Tool Room located in the St. Louis Park facility.

The space reduction is a result of the following: fewer machines having increased capabilities; interdepartmental sharing of machine resources; pre-planning and online scheduling of all fabricating work; reduced staging areas; part inspection is completed at the manufacturing site for most parts; dedicated, continuous product cells for high volume parts; work and capability consolidation of St. Louis Park Tool Room with Stinson Tool Room/Model Shop; and use of Model Shop for low volume production parts.

The Fabrication Facility consists of five functional areas:

1. Production Control
2. Production Engineering
3. Tool Design
4. Product Assurance
5. Manufacturing

PRODUCTION CONTROL

The Production Control area has been upgraded by implementation of all standard modules of the Honeywell Manufacturing System (HMS). Tools, models and rush jobs are manually processed into the HMS system to allow full control, scheduling, and allocation of machine resources in all areas. All work is prioritized. Tool fixtures, materials, gauges, machines, and human resources are scheduled for minimum delivery schedules. High, moderate, and low volume orders together with tools, models and unexpected spares orders are effectively controlled and scheduled by the Capacity Requirements Planning (CRP) module of HMS.

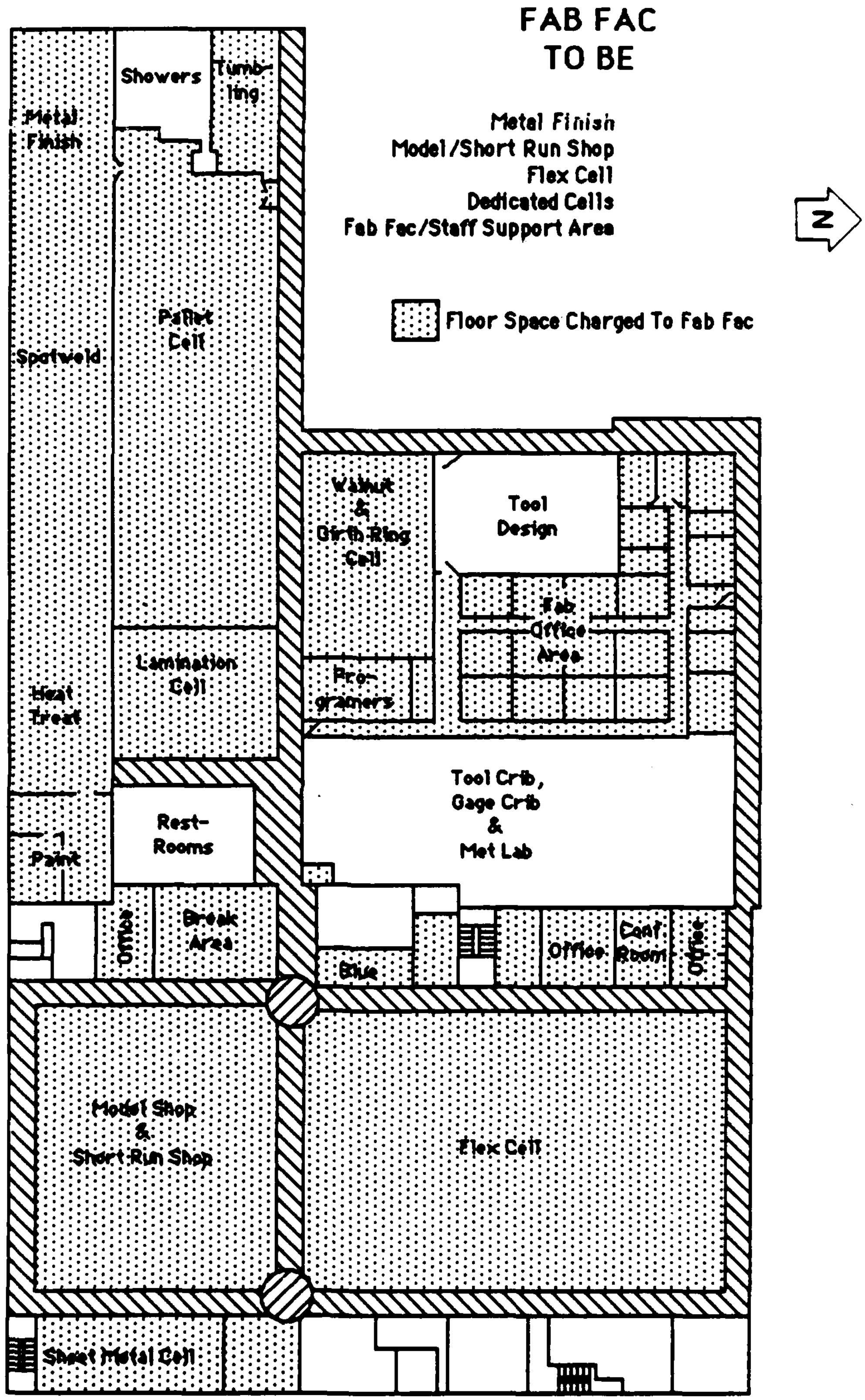


Figure 5.1 "To-Be" Fabrication Facility Floor Space Layout

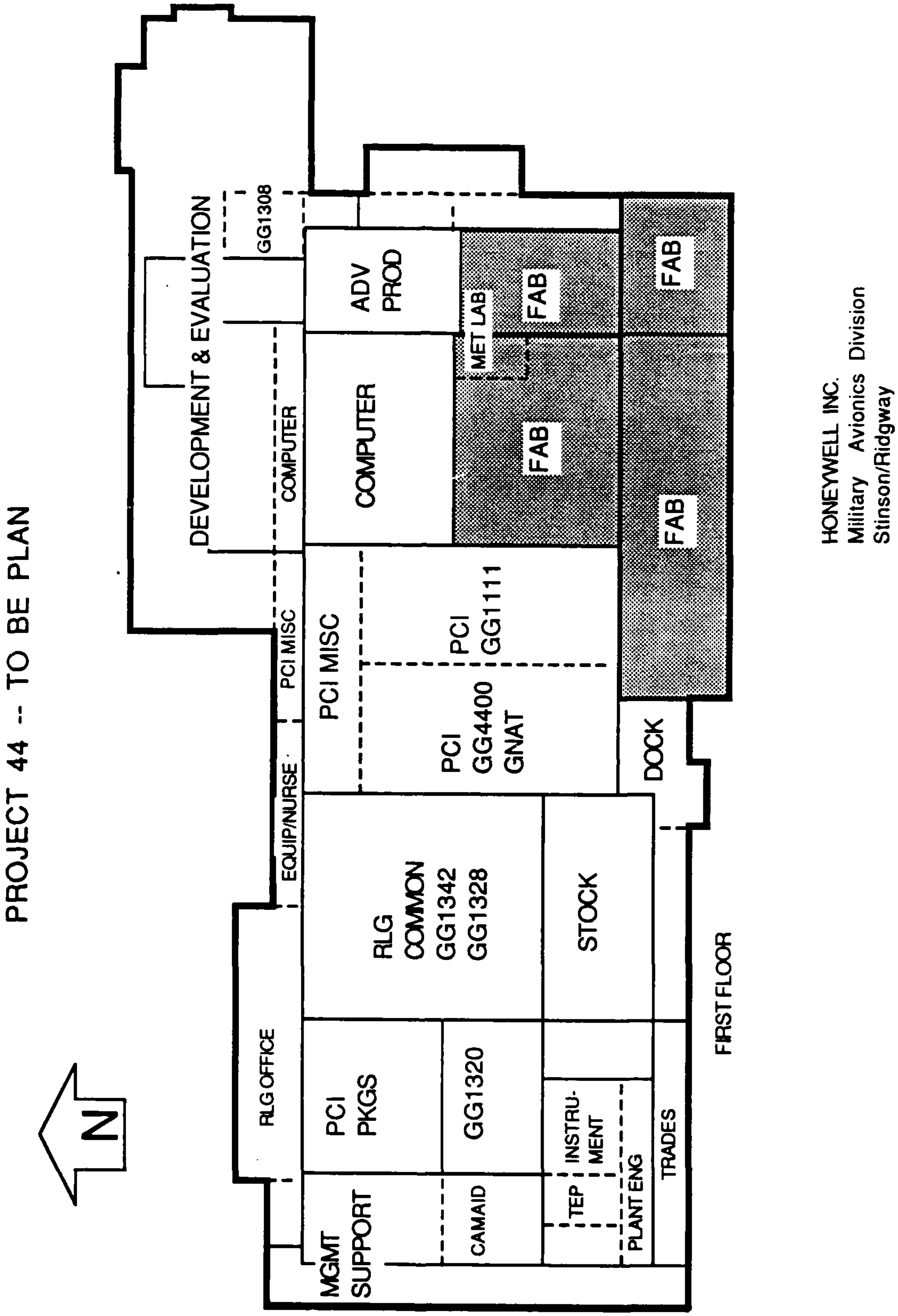


Figure 5.2 "To-Be" Stinson/Ridgway Facility

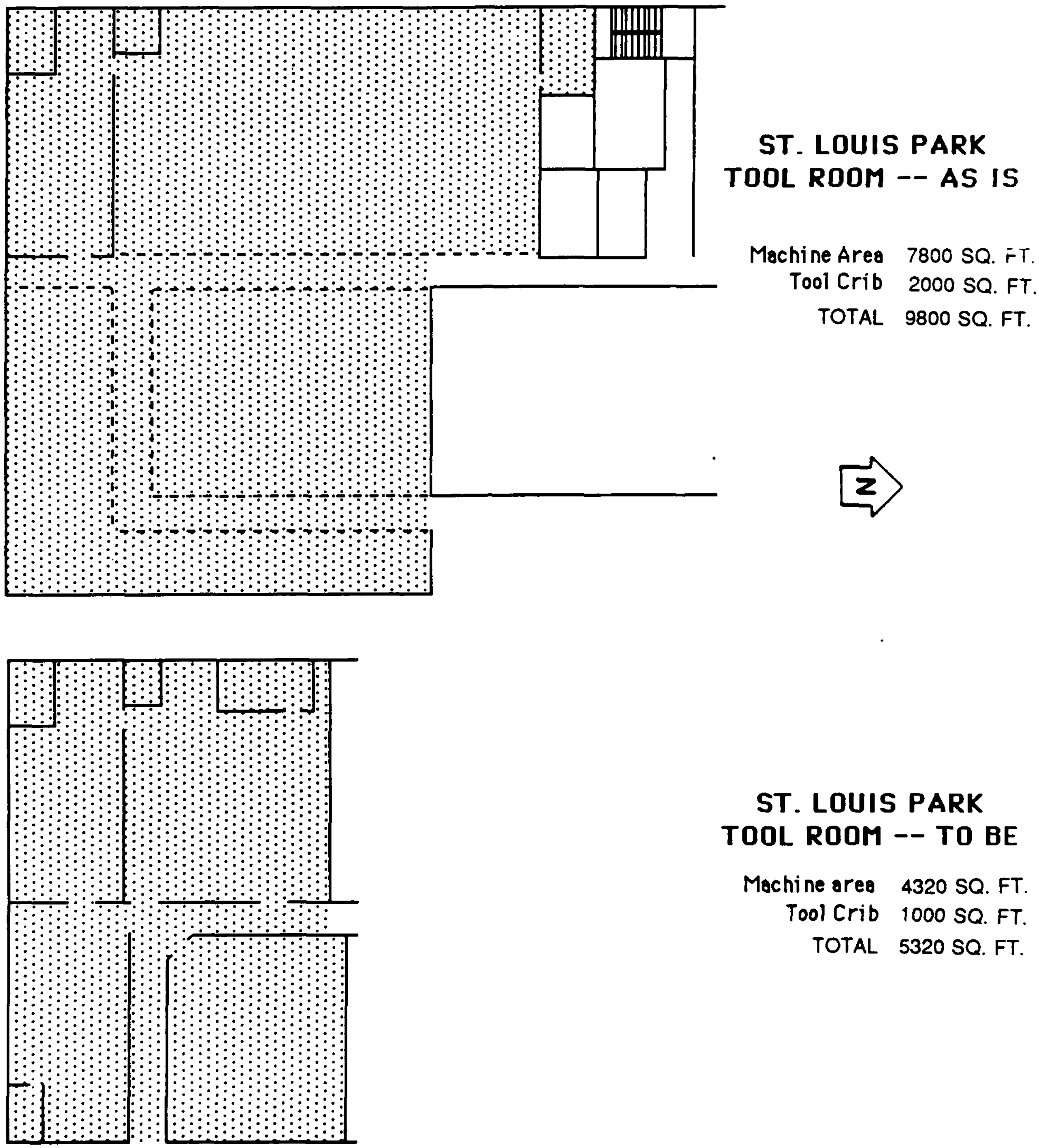


Figure 5.3 "To-Be" St. Louis Park Tool Room Layout (Comparative Areas)

The area is monitored through the use of an automated Factory Data Collection (FDC) system. This data is transmitted to the shop floor control module contained within HMS. Status update information is available to floor management, internal customers and other users of the system. The diverse production needs of the internal customer base are met without disruption or senior management directed reallocation of Fab Fac's manufacturing resources. Reference Figure 5.4 for the "To-Be" workflow.

PRODUCTION ENGINEERING

The Production Engineering (P.E.) function does not change. Less time is required to attend shop parts problems. Dedicated machine cells, flexible machining areas and centralization of factory responsibility for a parts cost, quality and delivery allow the engineering staff time to optimize and seal processes.

Production Engineers now work with the Tool/Model/Short Run Shop on new low volume parts that have volume or profit potential. Processes are documented by PE's to allow spare or emergency builds of higher volume parts to be run on compatible Short Run Shop machines.

NC programming remains a shared function with P.E.'s and hourly toolmakers. All NC programmers, both hourly and engineering, report directly to the P.E. supervisor. Scheduling of programming jobs to meet immediate production shop needs and HMS priorities is a P.E. responsibility. P.E.'s act as trainer and technical resource for NC programming, new factory equipment and systems.

TOOL DESIGN

Tool Designers now report administratively to Fab Fac. They remain a shared resource with all Honeywell business groups. They are a union work force that can be reallocated to other tool design groups on a city wide basis. They accept internal work on a cost transfer basis. Tool Design interaction with Fab Fac systems is further described in the "NC Programming Support Systems" and "Sheetmetal Cell" segments of this Final Report.

PRODUCT ASSURANCE

Most product assessment is now done as floor inspection in the area where the product is produced. Delays and unexpected rework are substantially reduced. Product assessment, for many parts, has become a shop floor function, with quality becoming an audit role. This subject is covered in detail in the Project 43 Final Report.

MANUFACTURING

The manufacturing area is divided into four departments.

1. Tool/Model/Short Run shop
2. Dedicated Machining Cell Area
3. Flexible Machining Area
4. Metal Finishing Shop

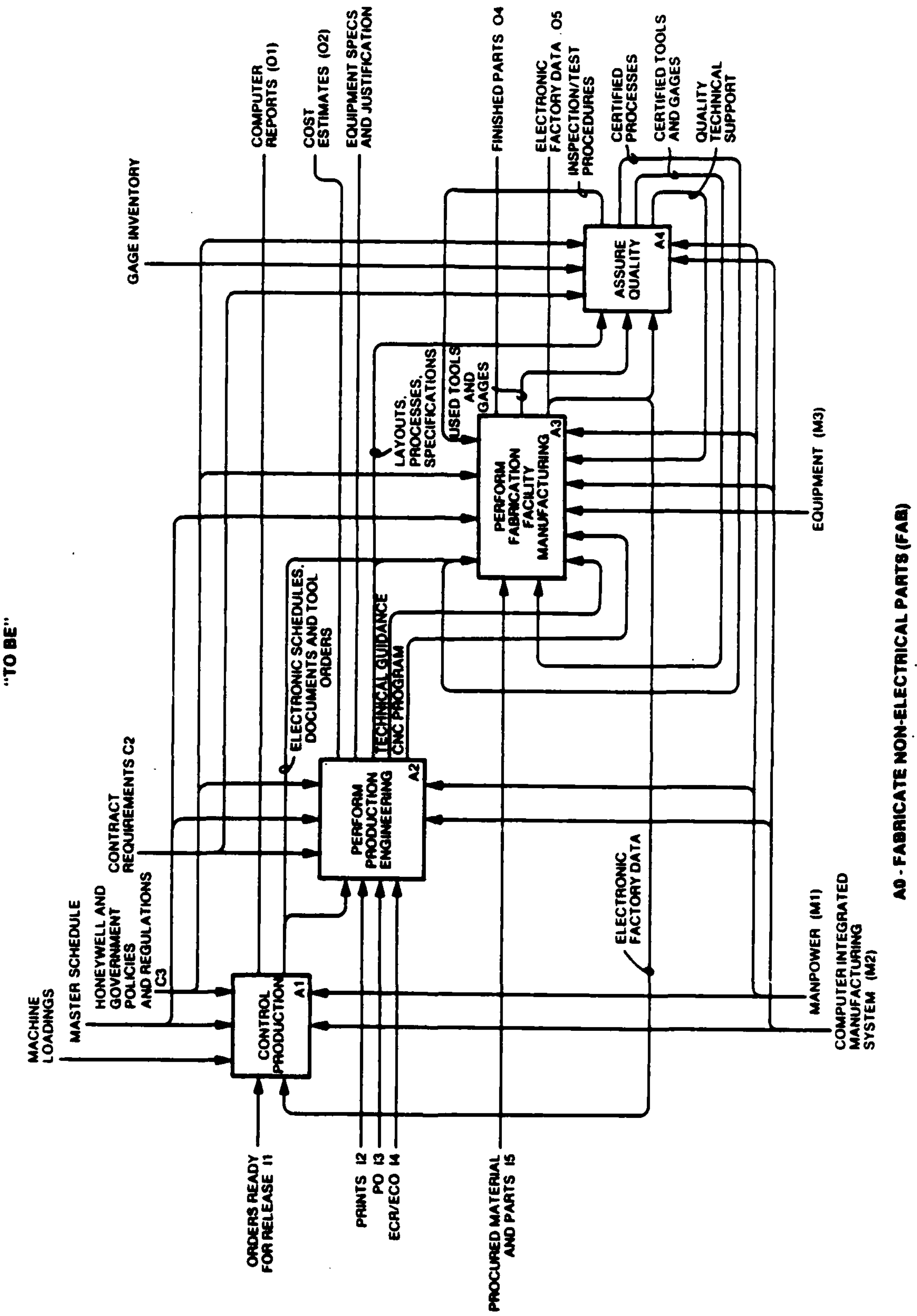


Figure 5.4 "To-Be" Fabrication Facility Workflow Diagram

Tool/Model/Short Run Shop (Stinson/Ridgway ar' St. Louis Park)

The shop at the Stinson/Ridgway facility supports extensive use of CNC, semi-automatic, and automatic equipment. The separate shops are controlled as a single administrative area. Work is frequently shifted for purpose of machine utilization. It is no longer a "traditional" tool room.

Structured (jobs which have a production process and have an alternate routing sheet for tool room) orders are scheduled by the HMS CRP system. New parts and unique applications are broken down into components, and processed and entered on the HMS system. Allowance for the reserve capacity to meet emergency and unplanned customer needs is maintained. If machine capacity is available, moderate run jobs from the Flexible Machining area are run on tool room machines to meet utilization requirements. Dedicated fixtures are built for specialized repetitive and long-run applications. Fixtures fit on qualified vice collet or general purpose tool plates on machines to reduce set up time. NC programs and tooling are certified to reduce inspection time. Fixture mounting patterns are standardized for all like or fixture sharing machines to allow flexibility in machine selection.

At the St. Louis Park shop there is extensive use of CNC, semi-automatic, and automatic equipment. As at Stinson/Ridgway, separate shops are controlled as a single administrative area. Work is frequently shifted for purpose of machine utilization. It is no longer a "traditional" tool room.

A single Toolmaker still has overall responsibility for a complete job. Operations to complete segments of a job are assigned to specialist areas within the tool room, or specific manufacturing resource in the Fab Facility. Tools, raw material, NC programs and instructions for desired result are prepared for and delivered to the work area to decrease non-reoccurring costs.

Machine resources are shared with the Flexible Machining Area on a routine basis. Other manufacturing resources are shared with all Fab Fac areas as directed by the HMS routings or special arrangements between supervisors.

A detailed discussion of this area is found in the "Model Shop/Short Run Shop/Flex Cell" and "Sheetmetal Cell" segments of this Final Report.

Dedicated Machining Cell Area

All dedicated work cells are controlled in one administrative area. Tools, gauges, fixtures, process instructions, inspection instructions, NC tapes (electronically stored) and general purpose tools are stored in the work cell area. Capital equipment is new or refurbished to the latest monitoring, feedback and part quality assessment devices.

A detailed discussion of this area is found in the "Walnut Cell", "T-Bar Cell", "Laser Cell", "Girth Ring Cell", "Pallet Cell" and "Lamination Cell" segments of this Final Report.

FLEXIBLE MACHINING AREA

Both moderate and high volume parts that do not pass machine utilization thresholds are produced in the Flexible Machining Area (Flex Shop). Although there is high variety in the processes, parts follow a predictable path through critical manufacturing resources. Part orders are issued with predictable regularity. Engineering and Production Control frequently review the parts population for planned transition to new or revised dedicated work cells or to construct alternate Short Run Shop manufacturing processes.

The Shop Supervisor is responsible for overall cost, quality and delivery of parts manufactured in the area. Processes that must be completed by outside resources are monitored closely. The Shop Supervisor and assigned Production Control person schedule and monitor the area with HMS and associated control/feedback systems discussed in the MIS section of this report.

A detailed discussion of this area is contained in the "Model Shop/Short Run Shop/Flex Cell" segment of this report.

Metal Finish Shop

The Metal Finish Shop acts as a supplier to the other Fab Fac manufacturing departments. HMS is used to tightly control schedule and capacities. Orders are scheduled by the MRP module. Critical resources are monitored and kept load leveled by the CRP module. Expendable supplies are procured in a timely manner with the purchased material control (PMC) module. Reserve capacity is maintained to support non firm planned rework or tool room "must have" jobs. The area remains a competitive/profitable alternative to subcontract by continuing to advance with new developments in plating technology.

There is some direct improvement in material handling and performance that results from storage and access made available by changes in surrounding areas of the shop. An inspection area and parts staging site is located by the new access corridor next to the Pallet Cell. Inspection equipment can, by non-destructive x-ray inspection, measure multi-plating layers. The area is supported locally by a Fab Chemical PE and the M&PE Lab at the Stinson/Ridgway building. The Metal Finish area continues to meet local EPA and internal safety requirements.

ANTICIPATED PROJECT BENEFITS

- Reduced piece part costs.
  Reduction in labor standards, due to new processes on new capital equipment, and reduction in actual time to produce parts in a more efficient area layout result in lower cost transfers to internal customers. These savings are reflected in lower costs to final customers as business is bid at actual experience.

- Reduced inventories.
  Paced, Just-in-Time and consistent delivery on HMS scheduled delivery dates allow "just-in-case" customer inventories to be reduced.

- Reduced work-in-process.
  Work cells, Flexible Machining Area and Short Run Shop manufacturing techniques result in substantial reduction in lead times and work-in-process.

- Reduced floor space.
  Consolidation of the Stinson/Ridgway with the St. Louis Park Tool Room capabilities; dedicated work cells; flexible machining lines; surplus of underutilized machines; common and utilization of capital resources by all manufacturing groups.

- Increased capability to respond to "must have" customer needs.
  Control of manufacturing capacities, allocation of reserve capacity and parallel processing in the Model Shop allows faster response to meet emergency customer needs.

- Reduced operator training.
  Operator training is reduced since there are fewer jobs for a person to master in an assigned area of Fab. *Specific parts are dedicated to specific machines.* Written documentation is improved for higher volume/repeating jobs. Machines self monitor many functions and inform operators of deviations. With the mingling of skill levels of assigned people in many areas, informal observations and on the job training between different operator levels occurs. People are able to observe and learn prior to formal transfer or assignment to a new machine/process. Formal training is required only for smaller, specific job functions.

- Reduced scrap and rework.
  Dedicated machines and continuous running processes, increased operator knowledge of specific jobs result in reduced scrap and rework.

- Machine maintenance and repair standardization.
  Machine selection has considered commonality of components in automated machines, which results in like maintenance procedures for machines of different manufacture. Fewer spare parts to stock and reduced training of servicemen result from standardization.

- Reduced fixture costs.
  Computerized manufacturing and tool room machines require fewer, simpler, less costly fixtures. Fixtures are built on CNC machines, which further reduces their cost.

- Increased optimum shop processes.
  Processes for work cells are "sealed". As part quality, training and machine problem are reduced, PE has more time available to study, improve and "seal" other volume jobs. Better processes yield more available engineering time and improved parts processes.

- Increased capabilities.
  New computerized machine tools and processes, such as laser welding, wire EDM and "live" tool turning machines, add capabilities to respond to new customer applications or to reprocess existing parts to exploit the added capabilities.

- Increased flexibility.
  By separation of low, moderate and high volume work the shop can respond to specific customer requirements with less overall shop disruption and improved effectiveness.

SECTION 6

PROJECT ASSUMPTIONS

The following assumptions have been incorporated into the development and implementation plan for the project. Alternatives or deviations to these assumptions could have an impact on schedules and/or costs of the project.

- Project assumptions reported in the project segments portions of this final report will be met.
- Project 44 Phase 3 proposals will approximately correspond to the segments of this Final Report.
- Implementation of project will not require changes in labor contract or practices.
- Market and business growth forecasts, used in the various project segments, will not be reduced prior to implementation.
- Work that is currently subcontracted can be brought in-house to meet project segment capacity requirements.
- Implementation of the project segments will be carried out by Fab Fac Production Engineering (PE) staff. The Fab Fac PE that was the team captain for the segment will be the "sponsor" during the funding and implementation of the project.
- Implementing PE staff members workload will be freed by sub contracting of recent retirees, or overload engineers.
- Actual capital equipment costs will be at current prices or bids current prices.
- There will not be a substantial industry accepted breakthrough in technology prior to implementation of each segment.
- Unless stated otherwise for a specific project segment, savings and capacities are based on two shifts per day, each of eight hours, five days a week (2.8.5) equipment usage with third shift and/or subcontract available for surge capacity.
- Inflation will not exceed 4% year after 1987 through 1991.
- HMS, and all standard modules, will be installed prior to the project implementation. HMS and FDC will perform as forecasted.
- This project will interface with other projects and management systems such as HMS, PMS, FDC, Projects 20, 43, 51 and 52 without modification.

- Capital funds will be available when required by the implementation plan.
- Floor space will be available by planned relocation of the Laser, Quality and Crib areas.
- Product/process verifications are successfully completed prior to implementation.

SECTION 7

GROUP TECHNOLOGY CODING SYSTEM ANALYSIS

The application of group technology as an analysis tool was of limited use in Project 44. There is no meaningful numbering system, except "tab" numbers, that describes like process characteristics in the approximate 10,640 summaries (routings) that comprise the potential shop order mixture.

"Tab" parts refers to prints and processes that are tabulated on a single print. Those features that have different dimensions that customize a part to a specific application are tabulated on the print. When parts have been processed, all operations that are common on a series of "tab" parts have a common process detail (work instruction) and summary operation number. The tab system has been used, by some business groups, to define a redesigned replacement part.

The manipulation of the investigative parts matrix (see Section 3 "Analysis Of Parts Base") made use of the process commonalities of often dissimilar products to develop potential work cell or flexible machining sequences for more detailed analysis.

SECTION 8

PRELIMINARY/FINAL DESIGN AND FINDINGS

The analysis of the parts that comprise the majority of the hours cost transferred to internal business groups suggested the manufacturing area should be restructured. A review of the equipment and current methods of the St. Louis Park and Stinson/Ridgway tool rooms suggested savings potential in both methods of production and equipment consolidation. A concept design for the shop was the complete consolidation of the two tool rooms, formation of a short run shop area, flexible machining area and work cells dedicated to high volume parts. It was assumed that Fab would discontinue all sheetmetal operations except limited tool room support. The proposed preliminary designs to support these concepts were:

- WALNUT CELL - The "Walnut" is a series of match machined gimbal assemblies for the GNAT series gyroscopes. This cell proposed to condense the manufacture of six piece parts and forty-four operations into an integrated area by use of existing Fab owned machines.

- T-BAR CELL - The "T" (Torsion) Bar is a series of miniature parts that mechanically transmit motion rates to output devices within the GNAT series gyroscopes. The cell proposed to consolidate turning, grinding, drilling, testing and feedback from testing to grinding .

- LAMINATION CELL - Laminations are bonded and machined gyroscope rotors, staters and peripheral devices. The cell proposed to consolidate the manufacturing, and responsibility, into a single area.

- GIRTH RING CELL - The "Girth Ring" cell is the GG1111 counterpart of the Walnut Cell described earlier. It proposed to combine turning, milling, drilling, grinding, laser welding, impregnation and metal finish into a single area.

- 1 1/2" BAR CELL - The 1 1/2" Bar Cell would accommodate parts of a maximum of 1 1/2" diameter. The GG1111 gyroscopes, GNAT gyroscopes, Helmet Sights (IHADDS) and Flight System Operations (FSO) suggested requirements for two or more machines.

- PALLET CELLS - The "Pallet" cell (palletized horizontal machining centers) proposed palletized loading, tool storage and retrieval and fixturing on a horizontal pallet machining center. Part volumes from PCI, FSO and CAvD indicated two or more machining centers would be required.

- DITHER SPRING CELL - The "Dither Spring" is a key-controlled component in the laser gyroscope. The cell proposed to combine turning, drilling, grinding, milling, wire EDM and bench operations.

- LASER BASE CELL - The "Laser Base" is the metal mounting base for the laser gyroscope. The proposed design wound combine milling, drilling, lapping, metal finish and helicoil insertion for the laser base and associated components.

- NC PROGRAMMING SUPPORT SYSTEM - To support conversion of parts moved to cells or the low volume work moved to the Model Shop, an NC support system was proposed.

- MODEL SHOP/SHORT RUN SHOP -This design proposed to provide the area, work environment and systems required to cost effectively process unique models or batches of parts while still supporting customer schedule requirements. Additionally, to implement a cost effective responsive system to produce batches of production parts where the normal manufacturing set up time exceeds the run time.

- FLEXIBLE MACHINING AREA - This design proposed a flexible machining area to process high and moderate volume parts. The area would be responsible for the cost, quality and delivery of parts.

As a result of the detailed investigations of these preliminary designs and changes in business conditions (as detailed in each segment's report), the following was concluded:

1) The "T" Bar Cell (grinding portion) - the turning parts merged with the 1 1/2" Bar Cell.

2) The 1 1/2" Bar Cell and Dither Spring Cell were combined with the Flexible Machining Area.

3) The Laser Base Cell (reported separately for clarity) was administratively merged into the Pallet Cell.

4) The Sheetmetal Cell concept was developed in response to changes in customer market forecasts.

5) The Model Shop, Short Run Shop and Flexible Machining area investigations/designs were merged to support equipment sharing concepts developed during investigative team interactions.

High volume parts, that passed both economic and utilization thresholds, are formed into work cells in one consolidated administrative area. The area is identified as the Pallet, Lamination, Walnut and Girth Ring cell areas. Fab resources, or vender operations, are expedited by the shop supervisor/production control team who have mutual cost, quality and delivery objectives.

A drawing of the final Fab Fac area layout is shown in Figures 8.1, 8.2, and 8.3. The Final Design is very close to the overall Fab Preliminary Design concept. It was agreed upon to include a figure for each section.

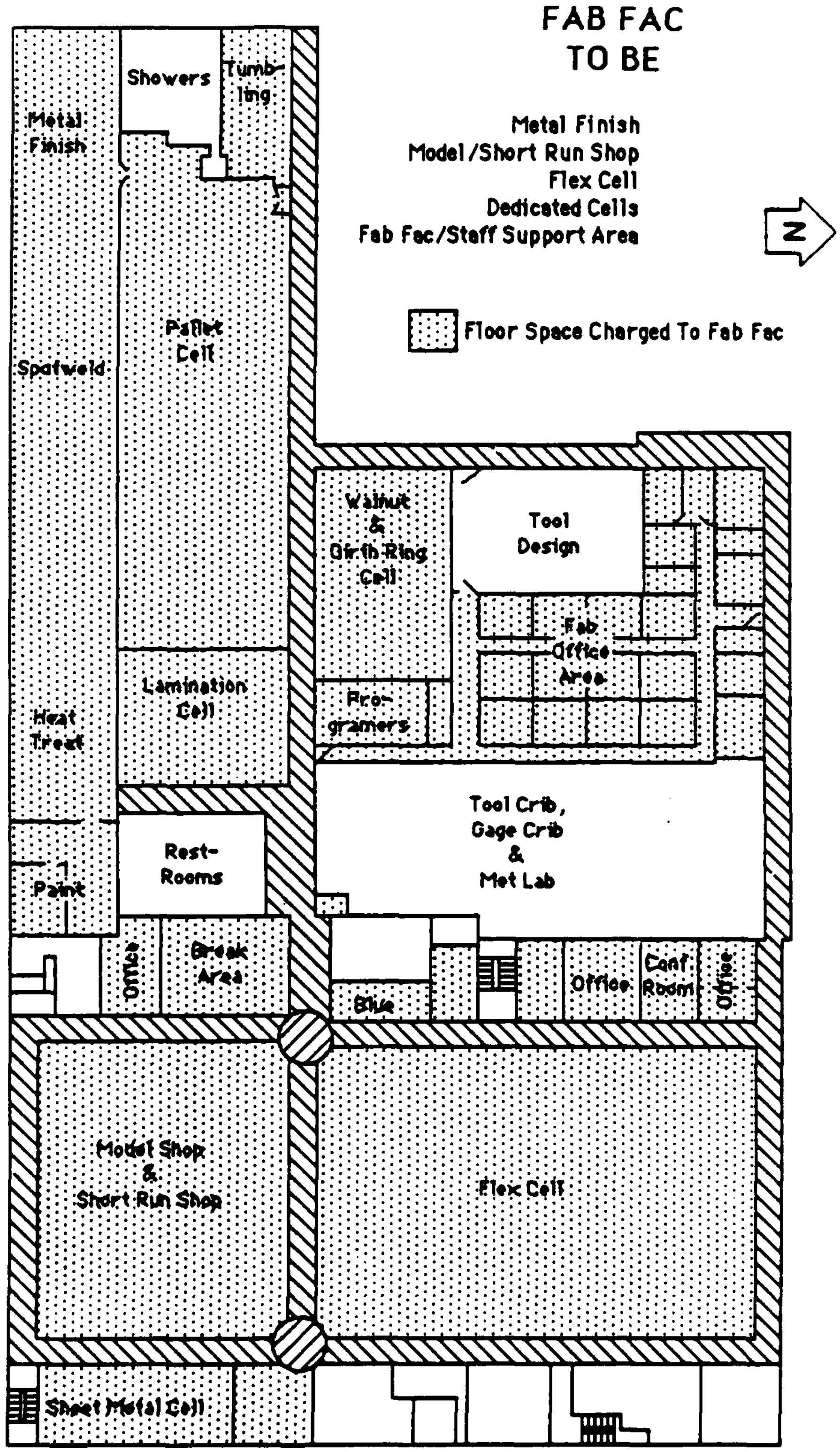


Figure 8.1 "To-Be" Fabrication Facility Floor Space Layout

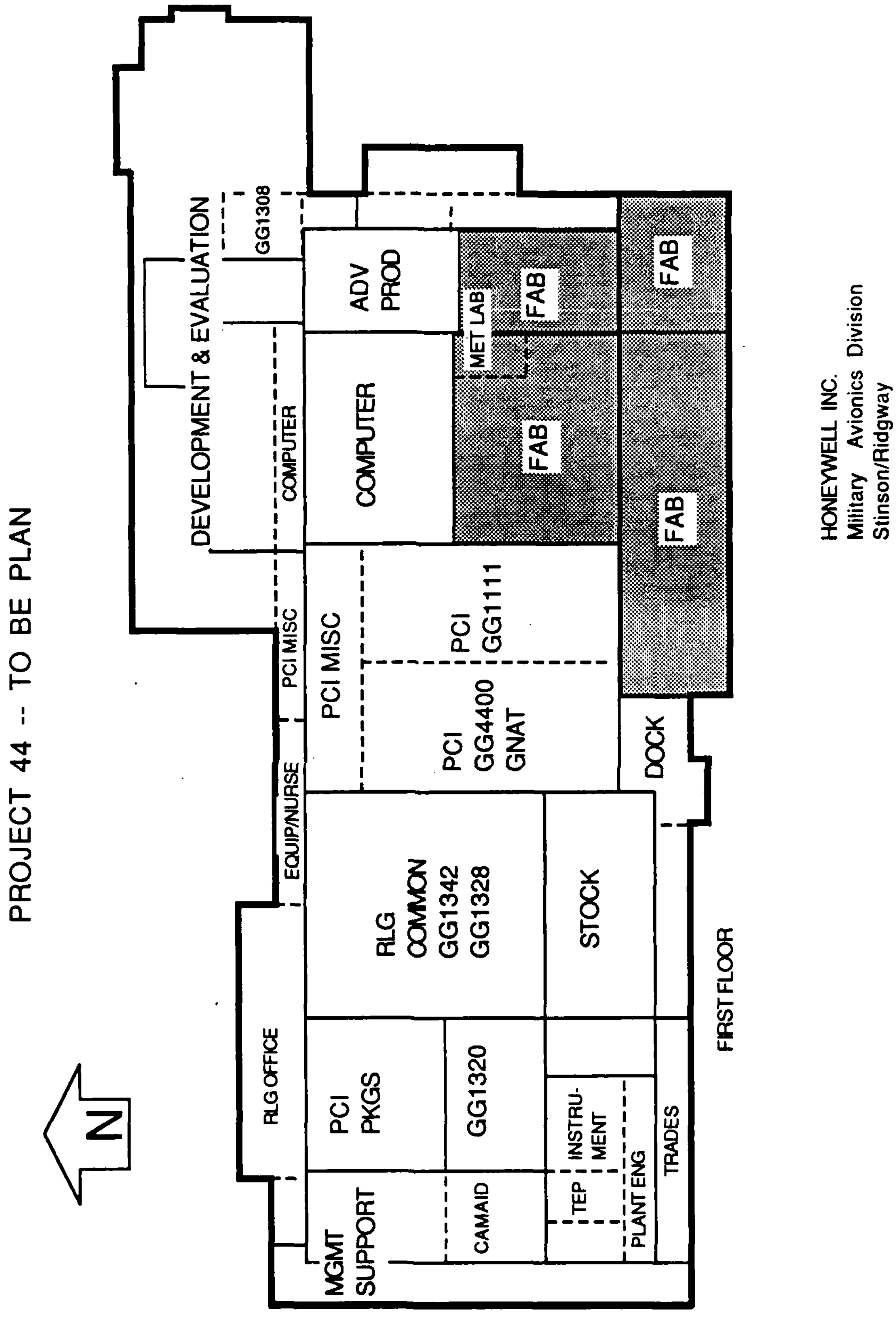
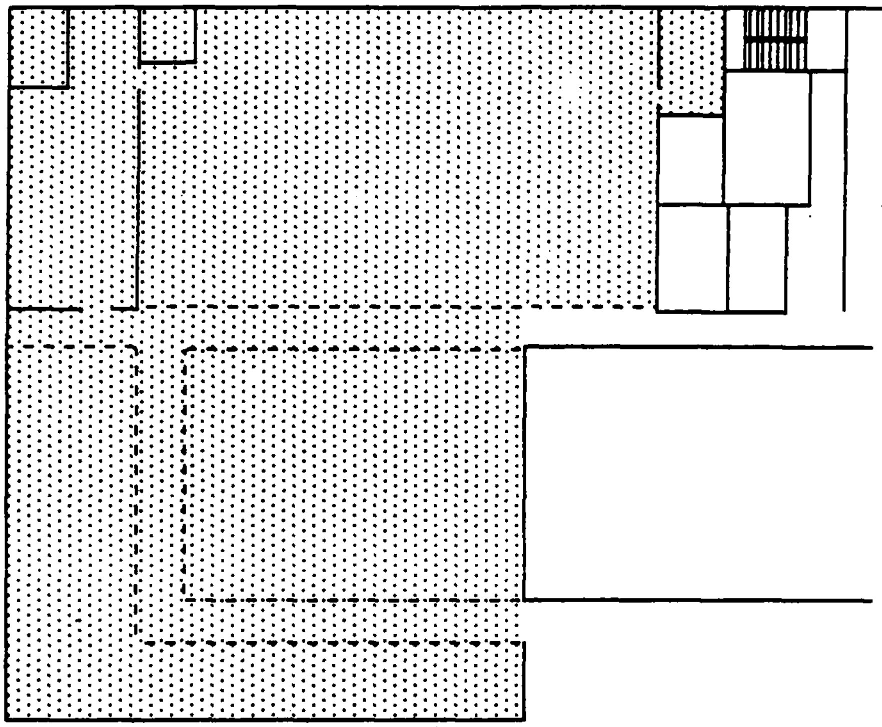
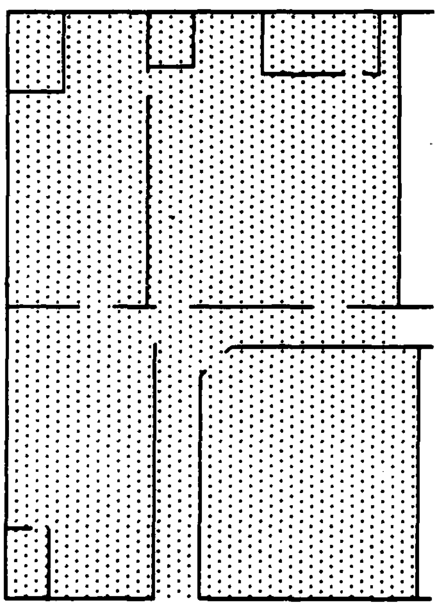


Figure 8.2 "To-Be" Stinson/Ridgway Facility



ST. LOUIS PARK
TOOL ROOM -- AS IS

Machine Area
Tool Crib



ST. LOUIS PARK
TOOL ROOM -- TO BE

Machine area
Tool Crib

Figure 8.3 "To-Be" St. Louis Park Tool Room Layout (Comparative Area)

SECTION 9

SYSTEM/EQUIPMENT/MACHINING SPECIFICATIONS

For specific discussion on Project 44 System/Equipment/Machining specifications, reference the project segments final report:

- WALNUT CELL
- MODEL SHOP/SHORT RUN SHOP/FLEX CELL
- T-BAR CELL
- LASER CELL
- GIRTH RING CELL
- PALLET CELL
- LAMINATION CELL
- NC PROGRAMMING SUPPORT SYSTEMS
- SHEETMETAL CELL

SECTION 10

TOOLING SPECIFICATIONS

For specific discussion on Project 44 Tooling Specifications, reference the project segment final reports:

- WALNUT CELL
- MODEL SHOP/SHORT RUN SHOP/FLEX CELL
- T-BAR CELL
- LASER CELL
- GIRTH RING CELL
- PALLET CELL
- LAMINATION CELL
- NC PROGRAMMING SUPPORT SYSTEMS
- SHEETMETAL CELL

SECTION 11

VENDOR/INDUSTRY ANALYSIS/FINDINGS

Vendor and capital equipment appraisals were complex due to the numbers of engineers and project segments being simultaneously evaluated. Without attentive consideration and coordination, there would have been vendor/project segments misunderstandings resulting in misquotes, no bids or improper specifications. A capital specialist production engineer has been assigned to the Fabrication Facility. His primary function is to maintain and catalog current information of new equipment, tooling, and manufacturing technologies applicable to Fabrication Facilities activities. This production engineer took the assignment of coordinating the following:

- Systems and capital equipment selections.
- Vendor proposed equipment, process and vendor evaluation.

An industry search was conducted to identify the companies that would be capable equipment supplier/integrators. In view of the many ongoing advances in machine tool automation and metal removal technology, we tend to think of modern mechanical manufacturing (CNC-Computer Numerical Control) a highly productive and efficient process. The information for preparing this evaluation was obtained by:

- Conducting an extensive literature search (local and foreign), Thomas Register, technical journals, advertisements, etc.
- Contacting suppliers.
- Contacting several suppliers and visiting a few companies.

In order to obtain detailed information, part drawings, and in some cases, sample parts were prepared and sent to selected companies to obtain first hand information and time estimates.

After review and assessment of the companies active in the market, several vendors were selected as appropriate, potential equipment suppliers for each project segment. They were selected based on the following criteria (not listed by priority or importance):

- Capability to deliver.
- Servicing and training support.
- Machine requirements and capabilities.
- Project support in supplying pertinent data.
- Size and financial stability (as indicated by Dunn & Bradstreet reports).

Although tool cost, which reflects both the price of the equipment and its durability, is important, it is not necessarily the paramount criterion. What is paramount, depending on objectives, is either minimum total cost of the machining operation or maximum production rate. Equipment utilization is very high because everything necessary to produce the parts are in one location while one operator runs multiple machines in the cell for optimum productivity.

The following is a list of companies contacted during the survey and Figure 11.1 identifies what equipment they provide:

- AMT-Anderson Machine Tool Company, Inc. - St. Paul, MN.
- Anderson O'Brien Inc - St. Paul, MN.
- Concept Machine Tool Sales - Minneapolis, MN.
- CIMCO - Naperville, IL.
- Dry-Tek - Wilmington, MA.
- Hales Machine Tools Inc. - Minneapolis, MN.
- Productivity Inc. - Minneapolis, MN.
- Q & S Machine Tool Company - Minneapolis, MN.
- Cincinnati Milacron - Cincinnati, MN.
- Ellison Machinery Company - Minneapolis, MN.
- Fay Machinery Company - Minneapolis, MN.
- Milton Grandquist Company - Minneapolis, MN.
- Hegman Machine Tool Inc. - Minneapolis, MN.
- High-Tech Systems Inc. - Plymouth, MN.
- Kearney & Trecker Company - Milwaukee, WI.
- Midway Machine Engineering Company - St. Paul, MN.
- Productivity Inc. - Minneapolis, MN.
- Q & S Machine Tool Company - Minneapolis, MN.
- RAM Center Inc. - Cannon Falls, MN.
- W & S - Minneapolis, MN.

Also contacted were foreign equipment vendors through their U.S. contacts. They included:

- ASEA Robotics Inc.
- Agietron Corporation
- Danobat
- Hirschmann
- Index Corporation
- Japan EDM
- Okuma Machine
- Studer
- Tschudi
- Toyoda Machine
- Yamazen

VENDOR - EQUIPMENT AVAILABILITY CHART

VENDOR	TYPE OF CNC EQUIPMENT					
	TURNING	VERTICAL MACH. CNTR	EDM WIRE CUT	O.D. GRINDER	C'LESS GRINDER	JIG GRINDER
ANDERSON MACHINING	X	X		X	X	
CONCEPT MACHINING	X	X	X	X		X
CINCINNATI MILACRON		X		X		
ELLISON MACHINING	X	X				X
FAY MACHINING	X	X	X			
MILTON GRANRULST	X	X				
HEGMAN MACHINING	X	X		X		
HIGH-TECH		X	X			
HALES MACHINE CO.	X	X	X			
KEARNEY & TRECKER		X				
MIDWAY MACHINING						
PRODUCTIVITY	X	X	X	X	X	
Q & S	X	X	X	X		
RAM-CENTER						
W & S	X					
ASEA						
AGIETRON			X			
DANOBAT	X			X	X	
HIRSCHMANN	X				X	
INDEX	X					
JAPAX			X			
OKUMA	X					
STUDER				X		
TSCHUDIN				X		
TOYODA				X		
YAMAZEN	X					
CITIZEN	X					

Figure 11.1 Project 44 Equipment/Vendor Listing

SECTION 12

EQUIPMENT/MACHINERY ALTERNATIVES

For specific discussion on Project 44 Equipment/Machinery Alternatives, reference the project segment final reports :

- WALNUT CELL
- MODEL SHOP/SHORT RUN SHOP/FLEX CELL
- T-BAR CELL
- LASER CELL
- GIRTH RING CELL
- PALLET CELL
- LAMINATION CELL
- NC PROGRAMMING SUPPORT SYSTEMS
- SHEETMETAL CELL

SECTION 13

MIS REQUIREMENTS/IMPROVEMENTS

Honeywell MAvD has a plan in place to implement a new MRPII system, Honeywell Manufacturing System (HMS).

HMS is a modular system comprised of the following modules:

- Master Production Scheduling (MPS)
- Inventory Records Management (IRM)
- Manufacturing Data Control (MDC)
- Material Requirements Planning (MRP)
- Capacity Requirements Planning (CRP)
- Purchase Material Control (PMC)
- Production Cost Accounting (PCA)

Honeywell has implemented the Process Management System (PMS) to control process layouts (shop work instructions) and summaries (routings) used by the factory as part of the current Factory Order Generater (FOG) systems. The PMS system data locations are being structured by PE's and PC's to mesh with bridge software being written to pass PMS summaries directly into the MDC (routing) module of HMS. The electronic conversion will be transparent to PMS users. The FOG system, currently used by Fab Fac, will be replaced by the HMS system.

Fab Fac is currently participating in an HMS pilot with the Laser business group. Laser parts, manufactured by Fab, are being run concurrently on HMS and FOG. The pilot is also using a Honeywell developed Factory Data Collection (FDC) system. The FDC system will be used by the entire division concurrent with the use of HMS.

Some of Fab's internal customers will not be utilizing all of the HMS modules. Fab will be the only initial user of CRP. If the PMS system data locations are restructured, as planned, prior to CRP implementation in Fab, it will not effect Fab's ability to accurately plan capacities for critical manufacturing resources.

Fab Fac is very close in structure to the "traditional" metal cutting factory which HMS was designed to control. When HMS is fully implemented, it will meet all the MIS requirements of Fab Fac to realize the benefits of Project 44.

QUALITY INFORMATION SYSTEM

Fab is currently participating in a pilot for the Quality Information System (QIS) marketed by Honeywell Bull. This software package is oriented toward collection of inspection data, automatic Manufacturing Assembly Disposition Records (MADR), gauge recertification scheduling and a form of detailed work instructions. The QIS system, pending a successful pilot demonstration may have division wide applications. The QIS is fully discussed in Project's 44 Final Report.

COMPUTERVISION

Much of the product design base for parts manufactured in Fab is on a Computervision CADDS 3 and 4X system. It is planned to use this design base for process and NC program construction. Refer to the NC Programming Support Systems and Sheetmetal Cell segments of this final report for a discussion in proper context.

PROCESS LAYOUTS

When shop orders are released to the factory by the FOG system, a packet of shop instruction and process layouts issued from process folders by Document Control, are included. This will not change when HMS is implemented. For jobs of high annual volume, there may be multiple orders on the floor. If there are process changes to be made to these parts, all copies of the process layout must be manually updated. The system works well for low volume parts, which comprise the majority of actual shop orders. Since parts currently follow a complex route through the factory, it is the only practical way to provide current process information with out an extensive local file system.

With the high variety of work in Fab, the number of Engineering Change Orders, process reviews or changes, it is often difficult to locate a specific process folder to react to a factory floor questions. There can also be delays in releasing a new order if the folder has been checked out of Document Control and must be located to duplicate process documents for factory use.

For parts that will be completed in work cells or higher volume repeat orders in the Flexible Machining area, permanent process layouts will be filed at the machine where the work is performed. These permanent layouts will permit greater detail and clarity. They may include expanded document sizes, multiple colors, or other features required to clearly document a specific process. Documentation to the detail issue of the layouts will still be controlled by the electronic sign off procedure for approving parties on the PMS system and the detail revision number of each operation layout on the PMS Cover Sheet. The PMS Cover Sheet is computer generated for each HMS shop order.

The parts identified in the investigative parts base (Section 3) are being scheduled to have current process documentation reviewed and upgraded. The Process layouts are being converted to electronically generated images on personal computers. As each document is printed, the latest revision is manually signed by approving parties and the printed original stored in the process folder controlled by Document Control. These key documents will be stored in a central electronic file for review. Only signed processes released from Document Control will be used for order releases. When fully implemented, this will free engineering resources from clerical tasks and allow more time for technical tasks.

SECTION 14

COST BENEFIT ANALYSIS/PROCEDURE

OVERVIEW

The final analysis of Project 44 was based on seven independent fabrication cells or work areas, and one Numeric Control programming system. These included:

1. Walnut Cell

2. Model Shop/Short Run Shop/Flex Cell

3. Laser Cell

4. Girth Ring Cell

5. Pallet Cell

6. Lamination Cell

7. Sheetmetal Cell

Individual CBA's were generated for each of the cells and work areas. This breakdown simplified the savings analysis due to multiple implementation start dates and various methods of deriving savings.

Two major cost drivers were identified and used to calculate savings for this project. The first being actual standard hours which was analyzed on a cell by cell basis. The second driver was actual floor space. The floor space savings was analyzed on an overall Fabrication Facility (Fab Fac) basis and not broken down cell by cell. These cost drivers were identified using the methodology shown in the process diagram of Figure 14.1.

MANUFACTURING SCHEDULES

The cost drivers and their associated savings were based on manufacturing schedules. Due to complexity and accessibility, the following three methods were used to derive the ten year projections for each cell or work area:

1. Marketing plan volume projections by product device.

2. Current year volumes (piece part or hours) escalated by each related operation's (FSO, IIO, TSLO) revenue plan projections.

3. Current year volumes (piece part or hours) with no projected change.

PROJECT 44
COST BENEFIT ANALYSIS METHODOLOGY

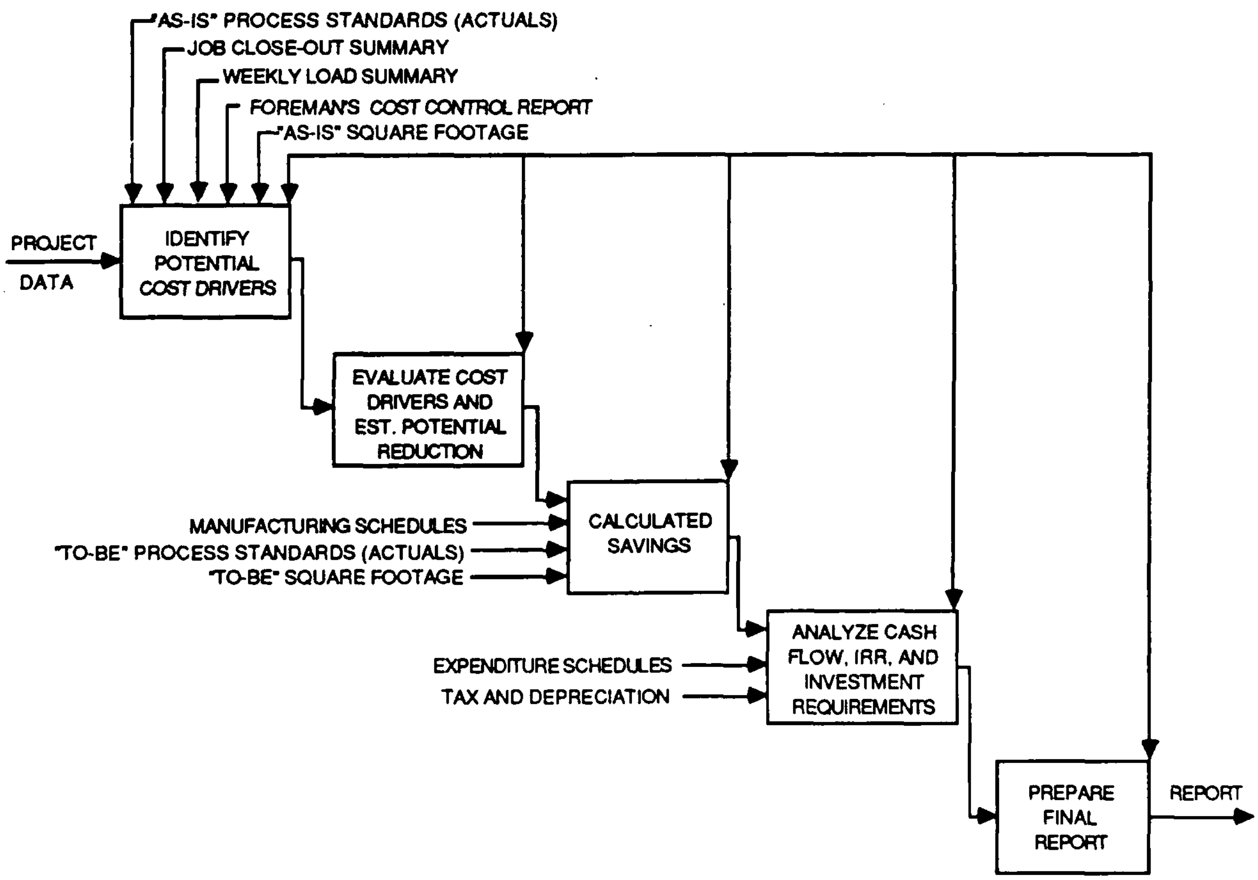


Figure 14.1 Project 44 Cost Benefit Analysis Methodology

After establishing projected volumes for each cell, an attrition rate was calculated and added to each cell's volume. These rates were based on past history by part number and received from Fab Fac's Production Control department. Not all part numbers in the analysis received an attrition rate due to the maturity of the part and/or availability of data.

ACTUAL STANDARD HOUR SAVINGS

The "As-Is" baseline for the dedicated work cells was taken form an internal Honeywell "Job Summary Report". This report listed the historical actual production hours generated by part number and job order number. The project team collected job orders from a range of years, late 1983 through 1985, to acquire a reliable sample size.

After gathering these hours, a computer program was developed to compile and establish average actual production hours per piece (see Figure 14.2). These average hours per piece were used as the "As-Is" baseline for calculating individual part number savings.

The "To-Be" standard hours for the dedicated cells were either established by Industrial Engineering or project consultants and Honeywell Production Engineers (P.E.'s). The time standards originally estimated by the project consultants or P.E.'s were reviewed and edited by Industrial Engineering staff.

An efficiency factor was added to the "To-Be" standard labor hour before savings were calculated. This factor was generated on a part number by part number basis. The factor was established by ratioing the "As-Is" average actual production hour per piece to the standard hour per piece. The standard hour per piece was taken from Honeywell's "Standard Hour Listing", which is a listing by part number of the frozen standards that are used to establish part and device costs on an annual basis.

This adjustment was required to make an objective comparison to the "As-Is" average actual hours for calculating savings.

Due to individual parts or assemblies currently having both assembly (Project 51/52) and Fabrication Facility (Project 44) labor performed, the department generating labor in the "To-Be" process will realize the savings. All "To-Be" processes will have no combination or cross-departmental parts or assemblies.

With the purchase of certain new CNC machining and Fabrication machinery, many presently sub-contracted parts will be produced in-house in the "To-Be" factory. To effectively calculate savings on these type of parts, Industrial Engineering converted the "To-Be" standard hours per piece to actual in-house cost per piece. An internal Honeywell make or buy/sourcing methodology was used to generate the "As-Is" and "To-Be" cost comparisons. This comparison utilized "To-Be" standard hours, projected departmental ratios, labor bid rates, originating burden (full burden less pro-rates), projected material conversion rates and vendor's quoted prices.

The remaining 1984 actual standard hours, not analyzed in the dedicated cells, were compiled and categorized by pre-determined manufacturing machine types. Examples of these are turning, milling, grinding, and miscellaneous. A select portion of those hours were addressed to realize an actual savings. The remaining will have no process change or improvement and therefore, not analyzed in the CBA. The individual sub-sections of the CBA will further discuss the methodology used.

FLOOR SPACE SAVINGS

The implementation of dedicated work cells and new state-of-the-art CNC machines proved to have a positive impact on the floor space required for the Fabrication Facility and Tool Room/Model Shop areas. A reduction of square footage will occur in the Stinson/Ridgway facility and St. Louis Part plant.

CAPITAL AND EXPENSE

The capital, recurring and non-recurring expense for Project 44 are shown in Figure 14.3.

PROJECT SAVINGS AND CASH FLOWS

The savings to be realized by this project exceed Honeywell's Military Avionics Division hurdle rate. The Projects' cash flows are shown in Figure 14.4 with the assumption that capital is available per the implementation plan.

PART NUMBER	END ITEM	CELL NO.	JOB NO.	DATE START	DATE FINISH	QTY SRT	QTY FIN	4004 SU	4004 RUN	4004 RWK	4005 SU	4005 RUN	4005 RWK	4006 SU	4006 RUN	4006 RWK	4007 SU	4007 RUN	4007 RWK	6154 SU	6154 RUN	6154 RWK	TOTAL MINUS DEPT 6154 SU	TOTAL MINUS DEPT 6154 RUN	TOTAL MINUS DEPT 6154 RWK
			6475	081083	041784	745	724	6.5	87.0	1.5	1.0	159.0		14.5	227.4			16.5		20.1	14.6	2.0	22	489.9	1.5
			6476	081083	062184	478	426	3.9	51.9		1.0	99.2		3.0	128.4	2.0		10.1		7.8	17.7		7.9	289.6	2
			6477	081083	070284	500	483	1.0	55.7		.5	107.9		8.8	228.5			11.5		15.8	12.5		10.3	403.6	
			6289	042583	020284	472	517	4.3	54.2	11.5	3.0	84.0	1.5	4.5	161.0	3.0		11.9	6.8	21.2	19.0	1.3	11.8	311.1	22.8
			A555	051584	062584	47	35			2.0			1.1						i.3			1.0			4.4
TOTAL HOURS						2242	2185	15.7	248.8	15	5.5	450.1	2.6	30.8	745.3	5		50	8.1	64.9	63.8	4.3	52	1494.2	30.7
AVERAGE HOURS/PIECE								.0072	.11387	.0069	.0025	.20600	.0012	.0141	.34110	.0023	0	.02288	.0037				.0238	.68384	.0141

"AS-IS" AVERAGE LEAD TIME (DAYS) = 244

"AS-IS" AVERAGE ACTUAL MFG HRS/PIECE = .72174

"AS-IS" TOTAL INSPECTION HOURS = 133

"AS-IS" TOTAL INSPECTION HOURS/JOB = 26.6 AVERAGE LOT SIZE = 437

Figure 14.2 Average Actual Production Hours/Piece (Example)

PROJECT 44 SUMMARY EXPENDITURE SCHEDULE

		Cost	Capitalization Date
CAPITAL COSTS			
MACHINERY COSTS			
		$156,110	1986
		$1,652,493	1988
		$4,099,735	1989
		$1,751,031	1990

	SUB-TOTAL	$7,659,369	
FURNITURE COSTS			
		$0	1987
		$20,167	1988
		$72,881	1989
		$9,813	1990

	SUB-TOTAL	$102,861	
COMPUTER COSTS			
		$127,566	1987
		$120,287	1988
		$3,215	1989
		$1,608	1990

	SUB-TOTAL	$252,676	
		$156,110	1986
		$127,566	1987
		$1,792,946	1988
		$4,175,832	1989
		$1,762,451	1990

	TOTAL CAPITAL COSTS	$8,014,906	

		Cost	Year Expended
EXPENSE COSTS			
NON-RECURRING EXPENSES			
		$14,000	1986
		$2,500	1987
		$240,540	1988
		$316,180	1989
		$84,720	1990

	TOTAL NON-RECURRING	$643,940	
TOTAL CAPITAL + NON-RECURRING		$8,658,846	
RECURRING EXPENSES			
		$2,219	1988
		$2,882	1989
		$9,499	1990
		$24,349	1991
		$12,980	1992
	* TOTAL RECURRING	--------	
		$51,929	

* Expense starts in 2 years

Figure 14.3 Project 44 Expenditure Schedule

TECH MOD PHASE 2

PROJECT 44 TOTAL

PROJECT CASH FLOW SUMMARY
($000)

	1986	1987	1988	1989	1990	1991	1992	1993
Capital	$156.1	$127.6	$1,792.9	$4,175.8	$1,762.5	$0.0	$0.0	$0.0
Non-Recurring Expenses	$14.0	$2.5	$240.5	$316.2	$84.7	$0.0	$0.0	$0.0
Recurring Expenses	$0.0	$0.0	$2.2	$5.1	$14.6	$38.9	$51.9	$51.9
Total Savings	$0.0	$118.2	$444.7	$1,705.4	$4,362.5	$5,164.3	$5,452.7	$5,818.6
Depreciation	$15.6	$40.9	$228.1	$780.0	$1,223.9	$1,168.5	$832.3	$733.5

	1994	1995	1996	1997	1998	1999	2000	TOTAL
Capital	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	$8,014.9
Non-Recurring Expenses	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	$657.9
Recurring Expenses	$51.9	$51.9	$51.9	$51.9	$51.9	$51.9	$51.9	$527.9
Total Savings	$6,327.5	$6,837.0	$7,494.6	$8,065.2	$8,034.4	$5,823.0	$554.2	$66,192.3
Depreciation	$580.9	$501.6	$504.9	$514.4	$458.7	$264.8	$71.0	$8,014.9

Figure 14.4 Project 44 Cash Flows

SECTION 15

IMPLEMENTATION PLAN

Project's 44 implementation plan is a compilation of each segments implementation plan. Reference each project segment for a detailed discussion.

PROJECT SEGMENT	IMPLEMENTATION START DATE
• WALNUT CELL	1988
• MODEL SHOP/SHORT RUN SHOP/FLEX CELL	1988
• T-BAR CELL	ON HOLD
• LASER CELL	1988
• GIRTH RING CELL	1989
• PALLET CELL	1988
• LAMINATION CELL	1989
• NC PROGRAMMING SUPPORT SYSTEMS	1988
• SHEETMETAL CELL	1988

IMPLEMENTATION OVERVIEW

The Fabrication Facility is currently in an intermediate stage between the "As-Is" and "To-Be" floor plans. Concurrent with the Phase 2 study, a broad consolidation of departments was completed. The Miscellaneous Machining area equipment was dispersed among the remaining departments. The Grinding Department merged administratively with the Turning department. Grinding was relocated in the former Miscellaneous Machining area. The Laser tool room and soda blast rooms were relocated between the former Grinding and Turning areas.

The events described below and scheduled in Figure15.1 will complete the move sequence to match the overall "To-Be" Fab floor plan.

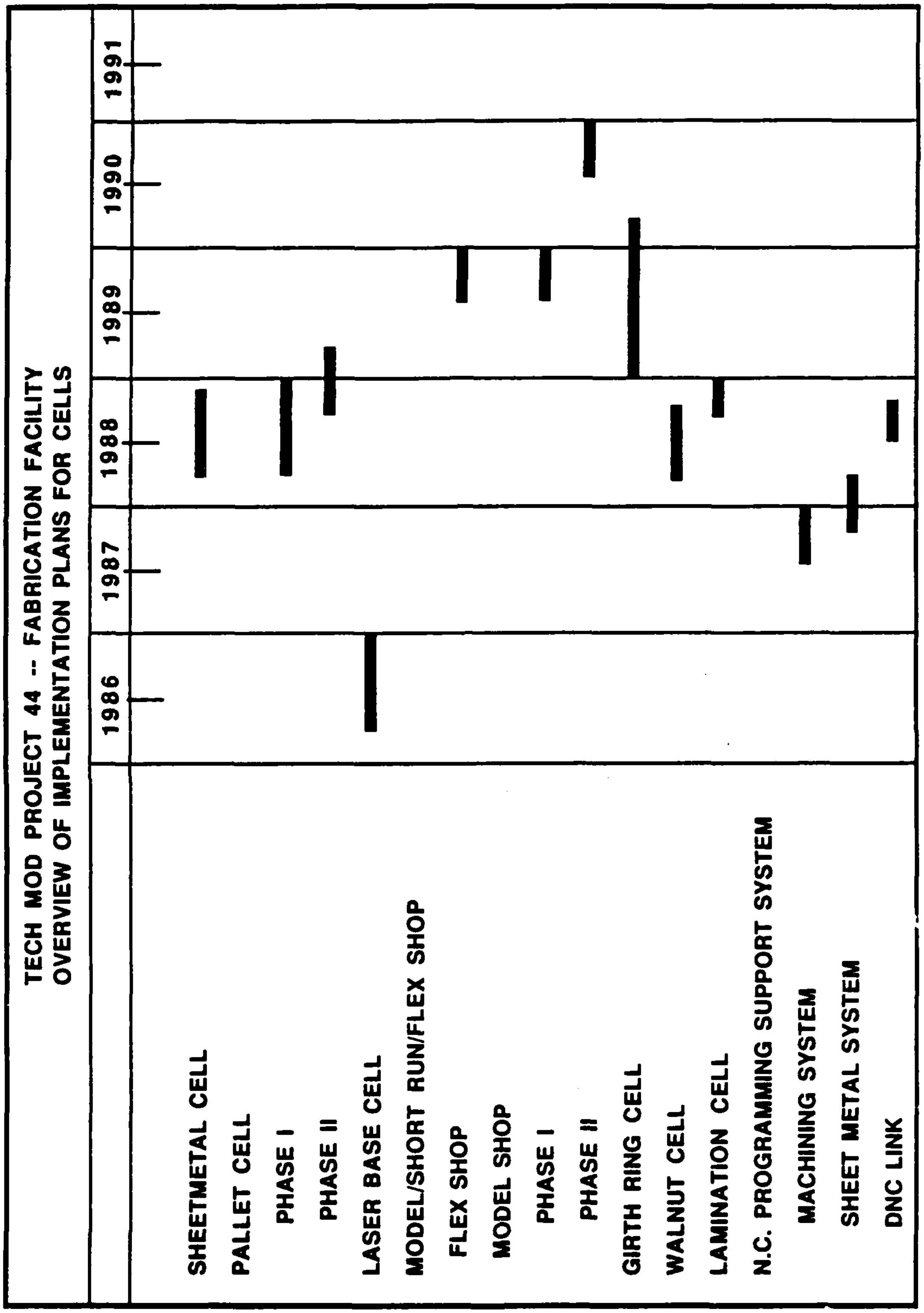


Figure 15.1 Project 44 Implementation Plan

1988

- Sheetmetal Cell - The entire cell can be installed in the existing equipment area. It can be scheduled independently of other project segments.

- Pallet Cells (will be installed during 1988 through 1989) - The entire cell can be installed in the existing equipment area. It can be scheduled independently of the other projects.

- Laser Base Cell completed. Schedule must coordinate with the Pallet Cell arrangement.

- Model/Short Run Shop, Turning and Grinding departments. Surplus machines that are not identified in "To-Be" Fab process. Reprocess or permanently subcontract identified capabilities as identified on process summary data base listed by manufacturing resource.

- M-76's (surplus from Pallet Cell area) moved to Tool Room/Short Run Shop.

- Laser business group vacates Glass Fab area. This must precede construction of the Programming room, Fab offices, Tool Gauge Crib, and Metrology Lab moves.

- Programmer room constructed.

- Installation of NC programming system begins.

- Fab office /support area reconstruction begins.

- Tool Crib (less material), Gauge Crib and Met Lab co-locate in the previous Glass Fab area.

- Final Inspection moves to new area by dock. This follows the building cafeteria move.

- Walnut Cell is installed in the area vacated by final inspection.

1989

- Girth Ring Cell installed in area vacated by final inspection.

- Lamination Cell installed. The move must be coordinated with the Pallet Cell completion.

- Modular work areas installed in Model Shop and excess work benches are surplused as new equipment is brought online.

- Common Model/Short Run Shop machines are relocated. All machines not identified in the "To-Be" plan are surplused as new machines are delivered.

- Purchase and install approximately 50% of Model/Short Run/Flexible Machining area.

1990

- Complete purchase/installation of equipment for Model/Short Run/Flexible Machining areas.

SECTION 16

PROBLEMS ENCOUNTERED AND HOW RESOLVED

Problem: Planned allocation of the Stinson/Ridgway building left Fab with a narrow "L" shaped area that was difficult to arrange for grouping of functional manufacturing areas and still maintain accessibility for efficient raw material delivery.

Solution: The first floor of the Stinson/Ridgeway building had to be reallocated by senior management.

Problem: Methodology for comparing Cost Benefit Analysis Model Shop "As-Is" to" To-Be" costs in a nonrepetitive tool room environment was felt to need pre-approval if there was to be a potential for shared savings.

Solution: Developed methodology and reviewed it with General Dynamics in order to gain approval.

Problem: Industrial Engineering support was not available as planned for the project. There was potential for significant misunderstandings between production and Industrial Engineers that would negatively impact results. There was potential for substandard CBA reports if the Industrial Engineer was unable to fully comprehend the project due to time considerations.

Solution: Project 44 shared an Industrial Engineer with 43, 51 and 52. The individual chosen had a previous background as a production engineer and previous experience as an Industrial Engineer in Fab. Weekly project meetings and planned daily contacts were made to keep both groups aware of project progress and needs of each functional area.

Problem: Ten year market forecasts were not available. Volume projections from several different sources did not match. Evaluation effort was spent on some concepts that would have been dropped had accurate part volumes been readily available.

Solution: The IIO Tech Mod Manager obtained traceable part volume or business area growth projections from the internal business groups that are Fab customers. These were factored or extrapolated to project part volume for specific or like parts in a ten year projection.

For additional discussion on problems encountered and how resolved, reference the project segment final reports :

- WALNUT CELL
- MODEL SHOP/SHORT RUN SHOP/FLEX CELL
- T-BAR CELL
- LASER CELL
- GIRTH RING CELL
- PALLET CELL
- LAMINATION CELL
- NC PROGRAMMING SUPPORT SYSTEMS
- SHEETMETAL CELL

SECTION 17

AREAS FOR FUTURE CONCERNS/DEVELOPMENT

- Successful implementation of the HMS/BOS system is vital to successful implementation of Project 44.
- Capital requirements to meet the Project implementation schedule do not match the "normal" five year capital plan allocation by business group. Capital will have to be obtained by modification of or outside of the current system.
- Significant changes in requirements of any of the business groups served by Fab could result in additions, revision, deletions or modification to the dedicated work cells planned for Fab.

For specific discussion on Project 44, "Areas For Future Concerns/Development", reference the project segment final reports:

- WALNUT CELL
- MODEL SHOP/SHORT RUN SHOP/FLEX CELL
- T-BAR CELL
- LASER CELL
- GIRTH RING CELL
- PALLET CELL
- LAMINATION CELL
- NC PROGRAMMING SUPPORT SYSTEMS
- SHEETMETAL CELL

PROJECT 44

LASER BASE CELL

SECTION 1

INTRODUCTION

The laser base is an aluminum die cast housing which supports internal components of the GG1342 package. The physical size of this piece part would fit into a box 1" X 6" X 8" long. Critical locating features require five mounting surfaces to be machined flat/coplaner within .0005". Various milling, drilling and tapping operations are performed on all surfaces to achieve final form. It is manufactured in the Fabrication Facility (Fab Fac) complete and delivered to the Ring Laser Gyro (RLG) area for assembly. Fab Fac's manufacturing structure is a traditional job shop which is organized into single disciplined departments, making the current manufacturing process inefficient.

With the market place growth of the RLG package, manufacturing order quantities continue to increase. Given this increase along with the laser bases's unique milling features and flatness requirements, this part lends itself to be grouped into a cellular manufacturing structure called the Laser Base Cell. This cell is comprised of the manufacturing disciplines needed to machine the laser base cost effectively.

SECTION 2

PROJECT PURPOSE/OVERVIEW

The objective of the Laser Base Cell is to improve productivity and throughput time for the Ring Laser Gyro (RLG). This was accomplished by establishing an "As-Is" manufacturing base and comparing this base to a "To-Be" condition. The justification of this cell was made from the savings between the two conditions.

Selection and placement of a CNC machining center, three ring lap and one standing height work surface was made to most efficiently and cost effectively manufacture the laser base and cover. The resultant process reduced product cost by: integrating multiple operations into one; reducing set-up time by changing fixturing and tooling; eliminating excessive material handling; and minimizing Work-In-Process (WIP) inventory.

SECTION 3

TECHNICAL APPROACH

The laser base housing and two variations of the gyroscope cover were analyzed and found suitable for a dedicated work cell. After analyzing the part configuration and studying the current processes, opportunities for improvement were identified. The approach taken to derive the Laser Base Cell proceeded as follows:

1. Manufacturing volumes were obtained through the Ring Laser Gyro's marketing department which created the base for capital justification and cell loading.

2. A thorough equipment and technology search was conducted to determine the best selection of equipment for this cell. Cellular arrangement of this equipment allowed improvements in manufacturing costs, part quality, tooling, fixturing and material handling.

3. A manufacturing "To-Be" process was established on each part. From the processes and projected marketing volumes, cell simulation, manpower requirements and cell capacity was derived.

4. Interfaces required to integrate the use of various existing and proposed operating and information systems was developed. These interfaces are: DNC programming link; Factory Data Collection (FDC); Honeywell Manufacturing System (HMS); Process Management Systems (PMS); and Quality Information System (QIS).

5. Confirmed the feasibility of the project by comparing the differential between the "As-Is" and "To-Be" manufacturing cost. A formal financial analysis of project savings, cash flows, expenses and IRR gave this confirmation.

6. After completion of the final design, an implementation schedule was prepared for the procurement and arrangement of machines and furniture.

SECTION 4

"AS-IS" PROCESS

INTRODUCTION

The laser base is an aluminum die cast housing which supports internal components of the GG1342 package. It is manufactured in the Fabrication Facility (Fab Fac) of Honeywell's Military Avionics Division complete and delivered to the Ring Laser Gyro (RLG) area for assembly. Fab Fac's manufacturing structure is a traditional job shop which is organized into single disciplined departments, making the current manufacturing process inefficient. The IDEF chart shown in Figure 4.1 shows the overall "As-Is" process.

The manufacturing sector of Fab is organized into single disciplined departments, performing one focussed operation. This type of discipline lends itself to inefficiencies in the "As-Is" manufacturing process for the parts dedicated to the Laser Base Cell. These inefficiencies are material flow, quality control and process requirements.

MATERIAL FLOW

The components identified for the Laser Base Cell follow a complex flow through the shop. Lot sizes of 500 are fabricated entirely by one department and moved between departments following layouts or process sheet instructions. Without centralization of these work areas, parts are moved from one end of the build g to the other with long delays. For the laser base, lead times of well over 300 days was not u.icommon. Storeroom personnel developed creative staging areas anywhere open floor space was available. This situation creates undesirable material flow conditions and causes difficulties in material control. Figure 4.2 demonstrates the present material flow condition for parts dedicated to the Laser Base Cell.

The current "As-Is" flow begins when castings are received from the subcontract vendor through the dock and stored in the raw material store room. After incoming inspection, lot sizes of 500 pieces are delivered to the NC Milling Department where the primary laser base mounting surface is milled in preparation for lapping. The parts are shipped to the Grinding Department for the bases first lapping operation. Stores personnel return the lot of parts to the NC Milling Department for the base's final milling and drilling operations. Without vacuum impregnation in-house, parts are subcontracted for this process operation. After incoming inspection, the laser bases are glass bead blasted and chromated in the Metal Finish Department. Installation of heli-coil fasteners in the NC Department prepares the parts for the application of a chemical film. From there, the laser bases receive the final lapping operation in the Grinding Department. Finally for corrosion protection, the bases are shipped to the Metal Finish Department for a final application of chromate. The completed parts are inspected and shipped to the central GG1342 stock assembly ready. At present, each base travels well over 2700 feet in the current shop, making this process inefficient.

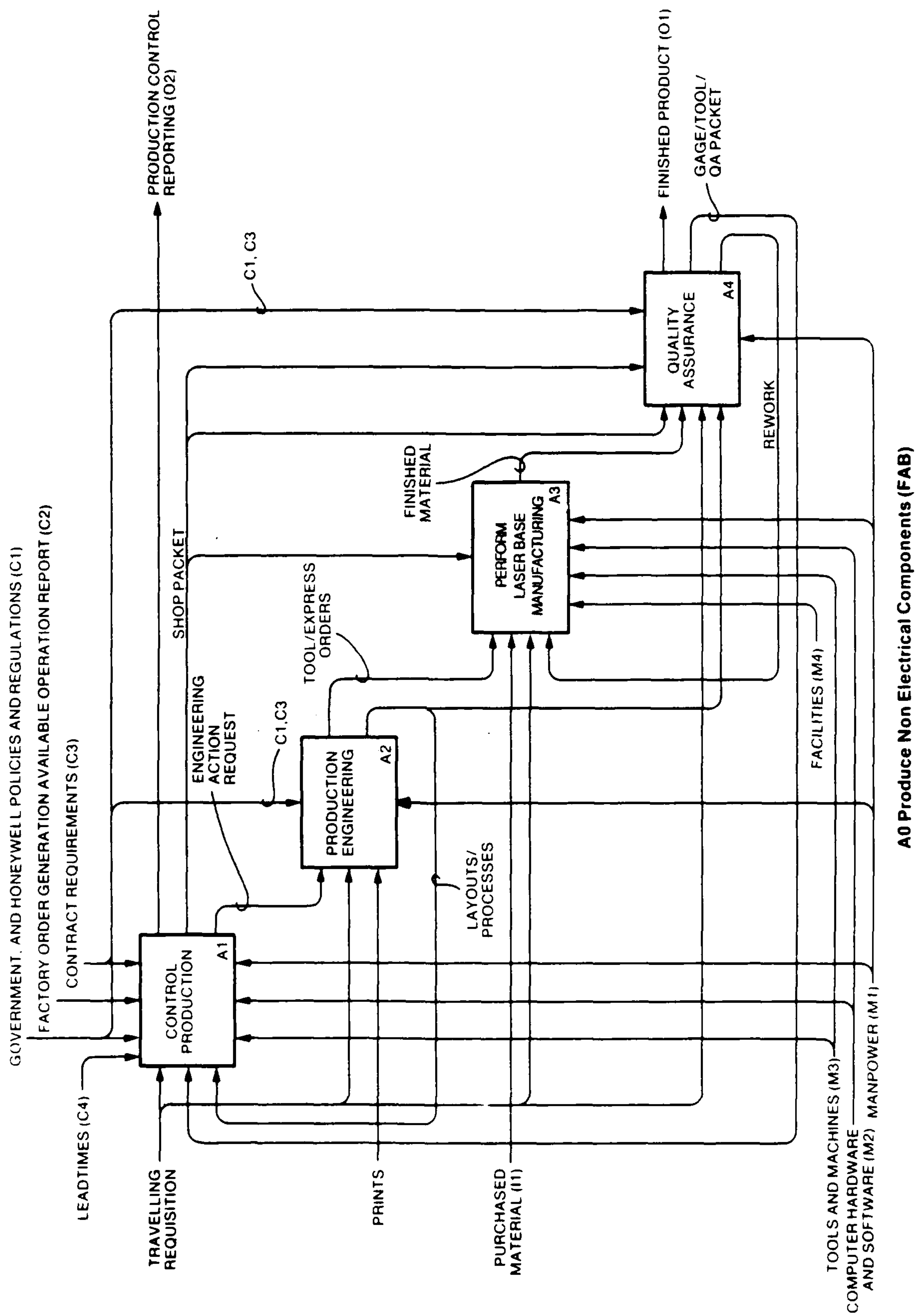
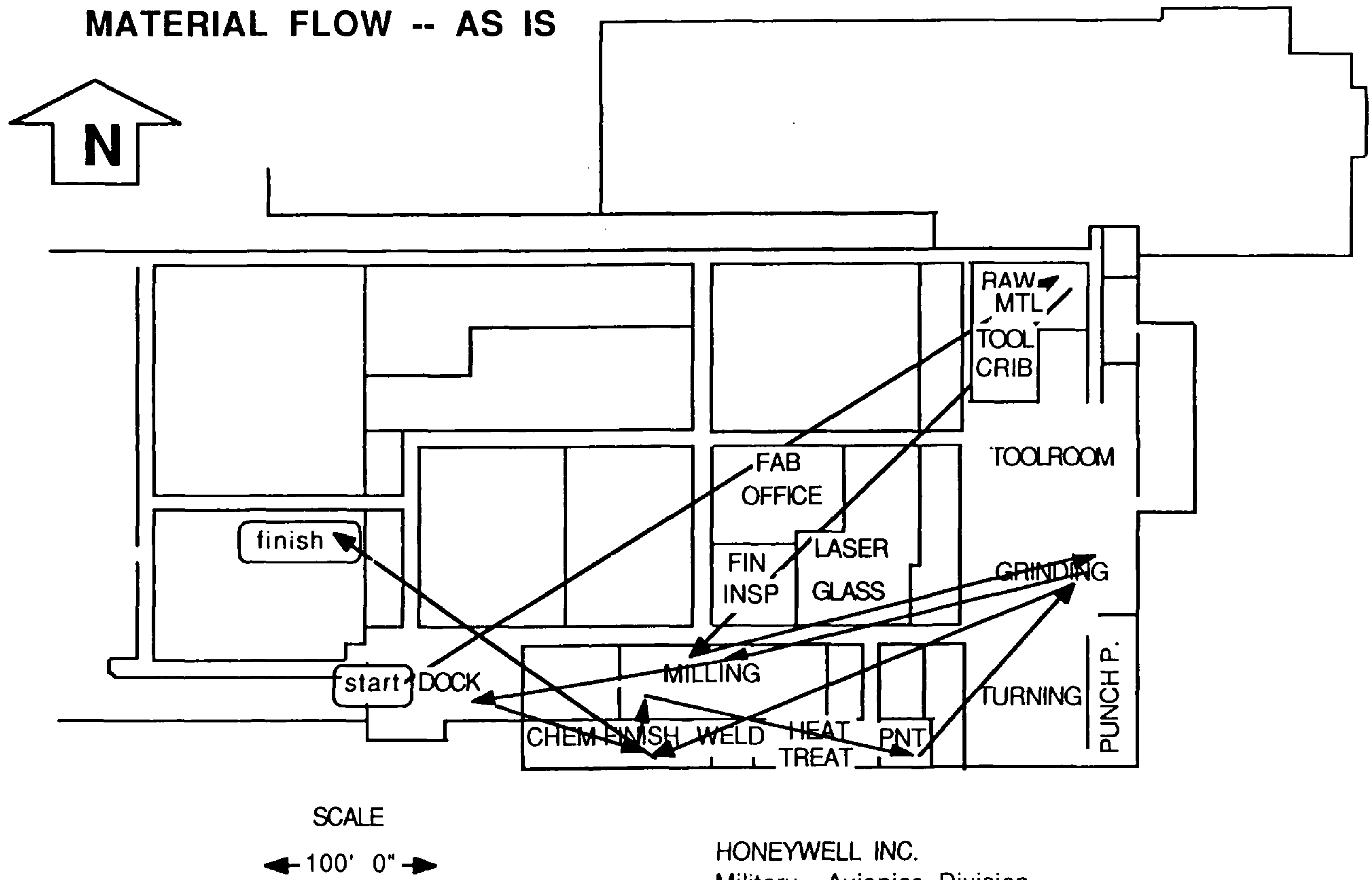


Figure 4.1 "As-Is" Laser Base Workflow Diagram

LASER BASE CELL FIRST FLOOR

MATERIAL FLOW -- AS IS



HONEYWELL INC.
Military Avionics Division
Stinson/Ridgway

This floor plan shows the complete material process flow of the manufacture of the laser base. At present each base travels over 2700 feet in the shop making 13 in process stops. This results in an average lead time of 350 days.

Figure 4.2 "As-Is" Laser Base Material Flow and Layout

QUALITY CONTROL

Parts are machined, and routed from machine to machine until an inspection operation is reached. The parts are then brought into the inspection staging area to be assigned a priority for inspection. After completion of inspection, parts are routed through the subsequent operations until another inspection operation is reached. If the parts are rejected and must be reworked, the entire lot is routed back into manufacturing causing additional delays due to machine loading capabilities.

PROCESS REQUIREMENTS

The sequential process flow diagram shown in Figure 4.3 identifies the "As-Is" manufacturing operations required to build the components selected for this cell. With single disciplined departments, it is necessary to duplicate manufacturing operations on the laser base in order to meet dimensional requirements. This duplication enhanced with subcontract impregnation inhibits a smooth flowing, cost effective manufacturing process.

LASER BASE CELL
AS IS PROCESS FLOW DIAGRAM

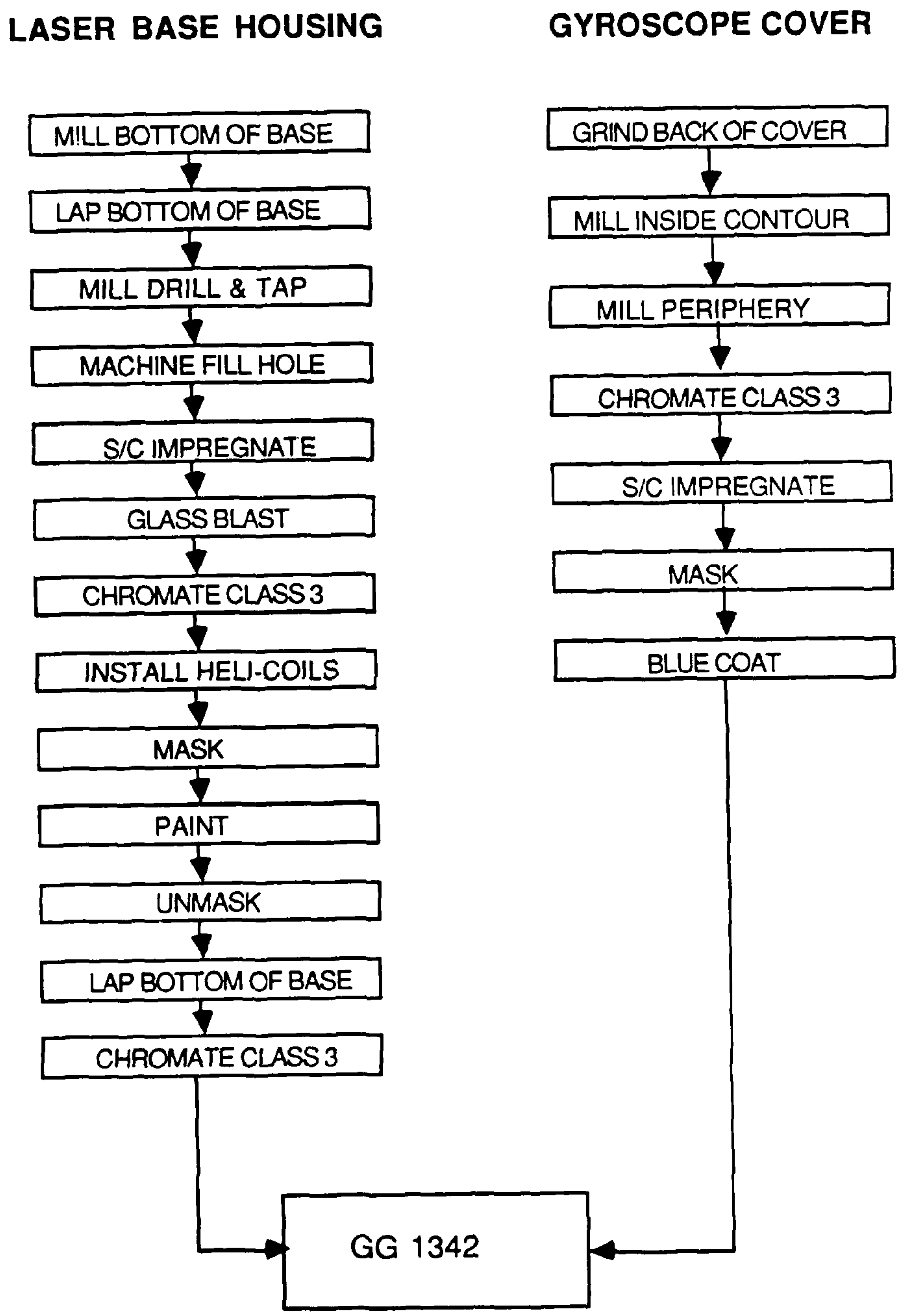


Figure 4.3 "As-Is" Laser Base Process Flow

SECTION 5

"TO-BE" PROCESS

INTRODUCTION

The manufacturing structure for the laser base housings and cover changed from single disciplined production departments to a dedicated manufacturing cell. Along with this change came improvements in the areas of material flow, process requirements, facility layout and quality control. These areas of improvement are described below.

MATERIAL FLOW

The overall workflow of the manufacturing process is diagrammed in Figure 5.1. This diagram shows a comprehensive flow of each control system and its tie to the overall manufacturing structure. Focussing attention to the section of the diagram labeled the "Laser Base Cell", the formation of this cell and its process simplified material flow and reduced the total part travel distance. The new material flow condition is shown in Figure 5.2.

The "To-Be" flow begins when castings are received from the subcontract vendor and stored in the stock room adjacent to the dock. After incoming inspection, lot sizes of 100 pieces are delivered to the Laser Base Cell located within the Pallet Cell area (reference Pallet Cell segment of this final report). Within this cell, complete machining of the base is accomplished by a lap and a vertical machining center. Parts are then transported to the Chemical Finish Department for a chromate treatment. At this point, an in-house vacuum impregnation operation is performed, sealing all casting porosity. All chemical treatments are complete at this point and heli-coils are inserted. Then the lot of laser bases are moved to the Paint Department for a final painting operation. Parts are inspected and moved to the stock room for assembly. A comparison of Figure 5.2 to Figure 4.2 demonstrates how the cellular manufacturing concept reduces the parts travel distance.

PROCESS REQUIREMENTS

The sequential process flow diagram shown in Figure 5.3 identifies the "To-Be" manufacturing operations required to build the components selected for the Laser Base Cell. The elimination of duplicated chromate and lapping operations resulted from parts control in a single working area. Set-up time for these parts is approaching zero. This was accomplished by using shared common tooling for each part, holding fixtures that are permanently set-up, and matrix controlled machine tool offsets. This set-up reduction allowed small lot sizes of 100 parts to be economically manufactured. With the addition of impregnation capabilities, all subcontracted operations were eliminated for this part family. As a result of this efficient manufacturing structure, lead times and work-in-process inventories are sharply reduced. Lead times of over 300 days are down to 21. Dependent on yearly order quantities and lot sizes, work-in-process inventories should not exceed 3.5 days of the cell's production (100 laser base housings).

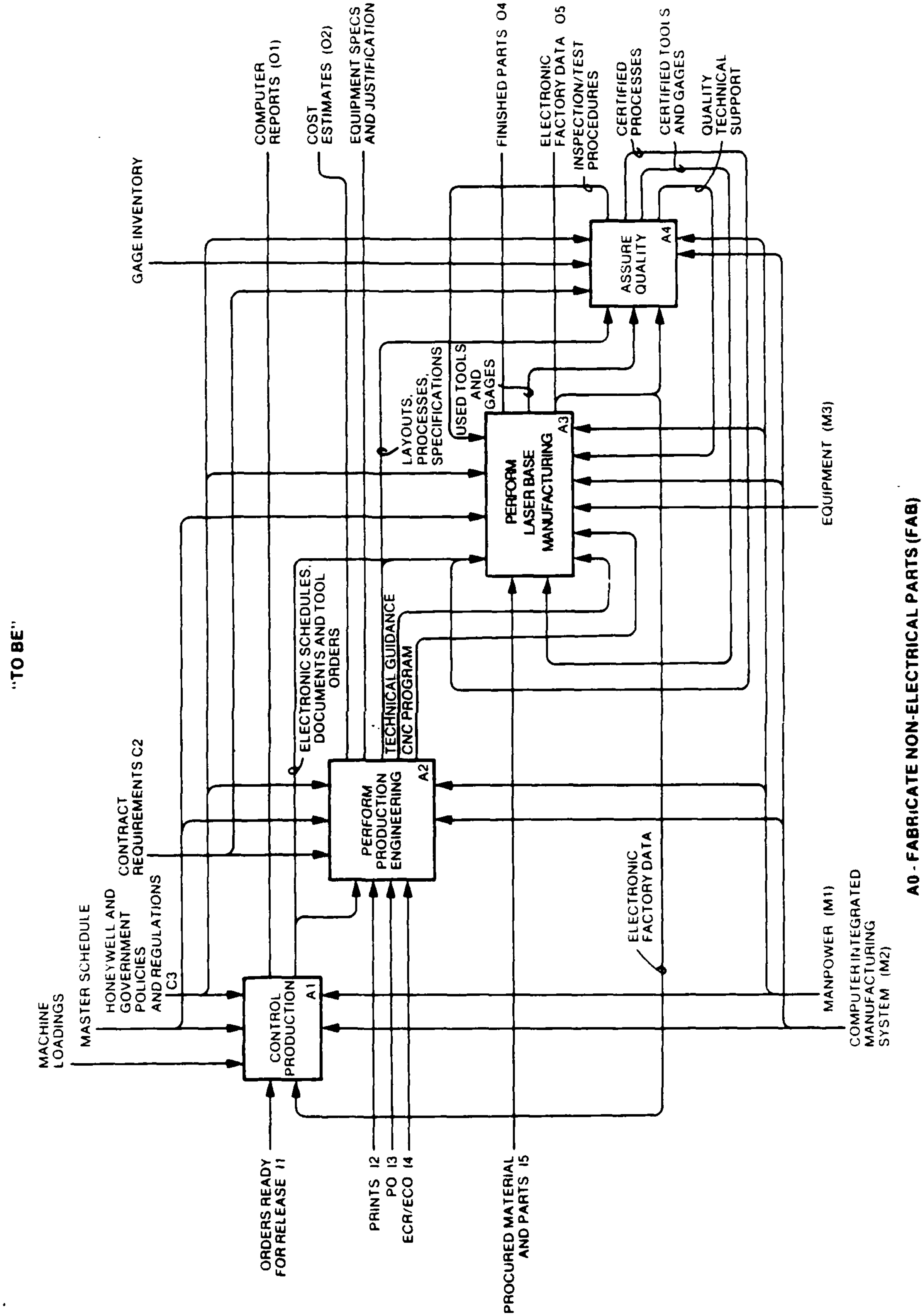


Figure 5.1 "To-Be" Laser Base Workflow Diagram

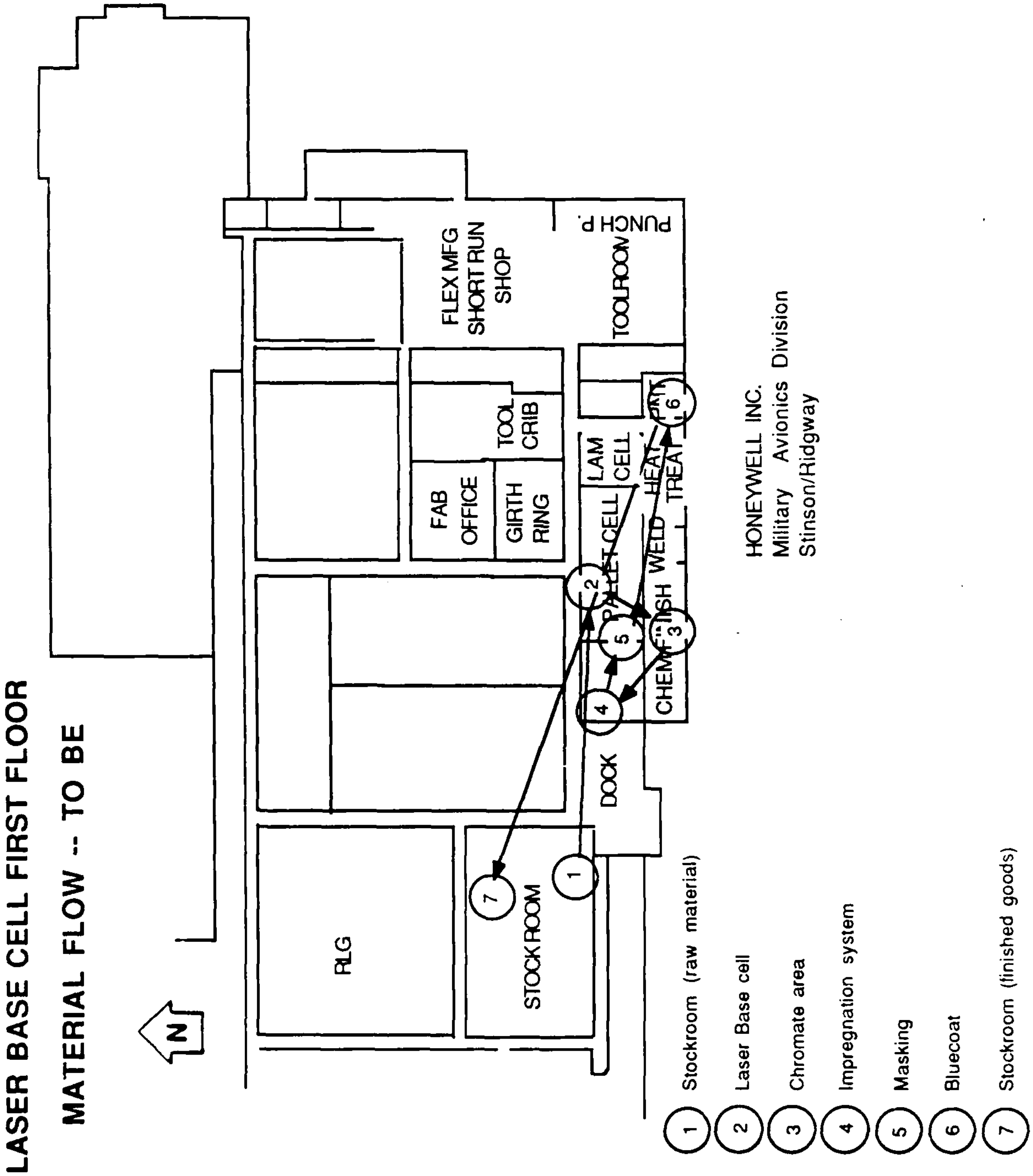


Figure 5.2 "To-Be" Laser Base Material Flow

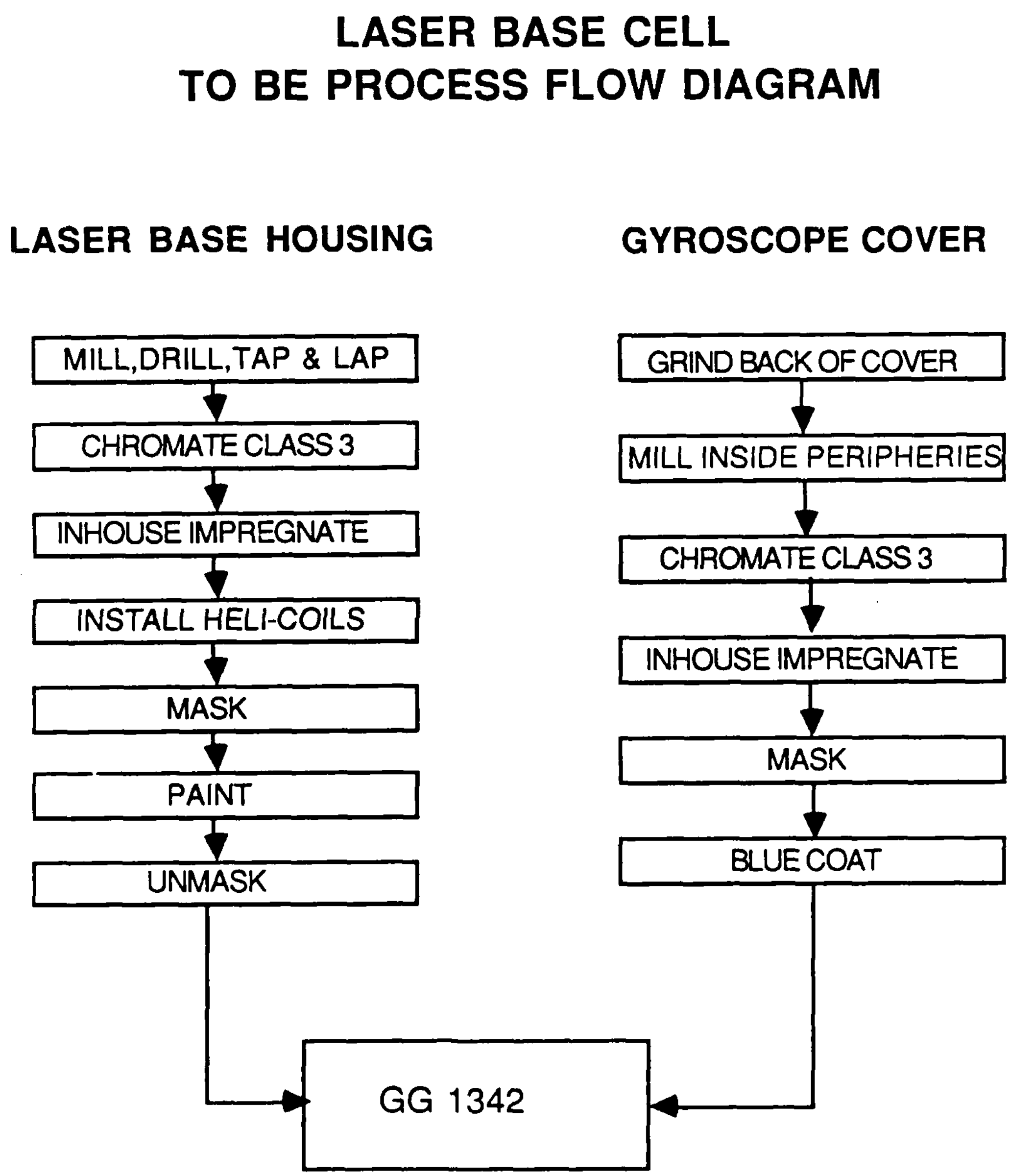


Figure 5.3 "To-Be" Laser Base Process Flow

FACILITY LAYOUT

The formation of the Laser Base Cell localizes metal removal operations into a cell area of 400 square feet. Figure 5.4 represents the "To-Be" cell layout including material flow. Within this layout, machine utilization for the vertical machining center (M76) is 141 percent. The 3 axis milling machine is equipped with a 20 tool station carousal, which allows tools for the laser base and gyroscope cover to be permanently set-up in the machine. The lapping machine is operated internally to the milling machine and its utilization is 31 percent. The lapping machines purpose is to hold flatness over 5 mounting surfaces. The utilization of these machines is based on two shifts of operation.

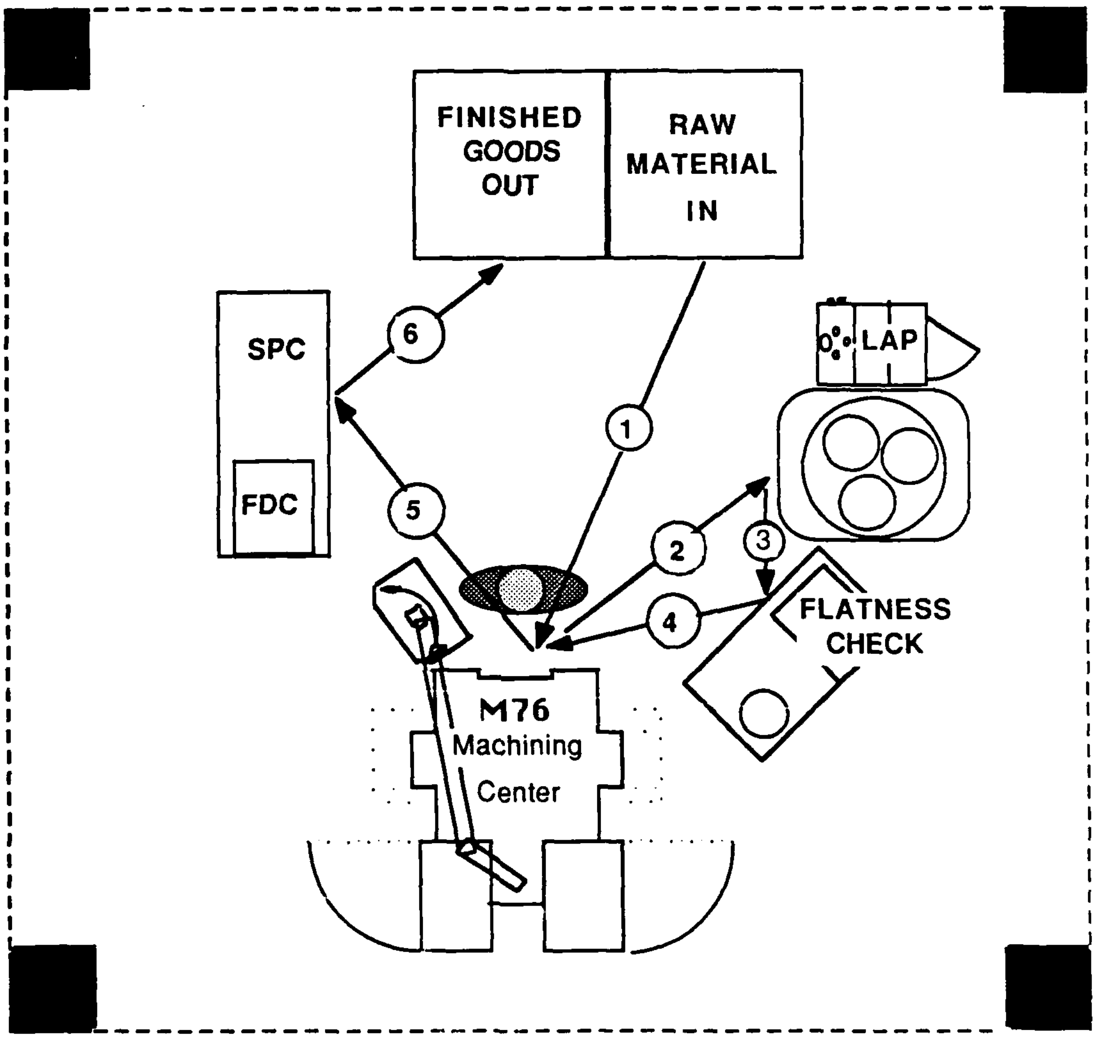
Manpower required to keep this cell in operation is one person per shift. This person electronically gages critical machining features and statistically controls the machining process. Feedback from this data allows the operator to make machine control changes when parts approach non-conformance.

Interaction with the Quality Information System which tracks tool wear, gauge recalibration and material non-conformances occurs in parallel with Factory Data Collection (FDC). FDC is used as a tool and aids the operator tracking quantity run, scrap and time reporting.

QUALITY CONTROL

The responsibility of quality falls in the hands of the production operator. Inspectors perform audit functions only in this cell. Ownership in the total quality of the part improves quality and throughput time while reducing scrap, rework and inspection costs. To help the operator in this task, electronic gauging equipment with a digital display is used. Quality information is down loaded to a data collector for use in process control and inspection audits.

LASER BASE CELL LAYOUT



MATERIAL FLOW

1. MILL, DRILL, & TAP BOTTOM
2. LAP BOTTOM
3. CHECK BOTTOM FOR FLATNESS
4. MILL DRILL & TAP COMPLETE
5. INSPECT
6. FINISHED GOODS OUT

Figure 5.4 "To-Be" Laser Base Cell Layout

SECTION 6

PROJECT ASSUMPTIONS

The following assumptions were made during the development of the Laser Base Cell.

- A one shift operation is based on 1700 standard hours per year.
- The vacuum impregnation chamber and vapor degreaser will be procured and used as shared resources with the Girth Ring, Walnut, Pallet and future manufacturing cells.
- Labor classification changes for this project are not limited by the present bargaining unit work.
- The floor space required for this cell will be made available the second quarter of 1988 with Laser Base Cell equipment to be moved concurrent with the Pallet Cell implementation.
- The design and operating capacity of this cell is contingent upon the forecasted volumes given volume sensitivity. The design structure of this cell will be replaced by new design requirements if the volumes increase/decrease out of its relevant range of measure.

SECTION 7

GROUP TECHNOLOGY CODING SYSTEM ANALYSIS

Group technology was not used in the formation or development of this cell.

SECTION 8

PRELIMINARY/FINAL DESIGN AND FINDINGS

Within the guidelines of the technical approach, as outlined in Section 3 of this report, the Laser Base Cell was developed to its final design. The approach taken to derive the Laser Base Cell is described below.

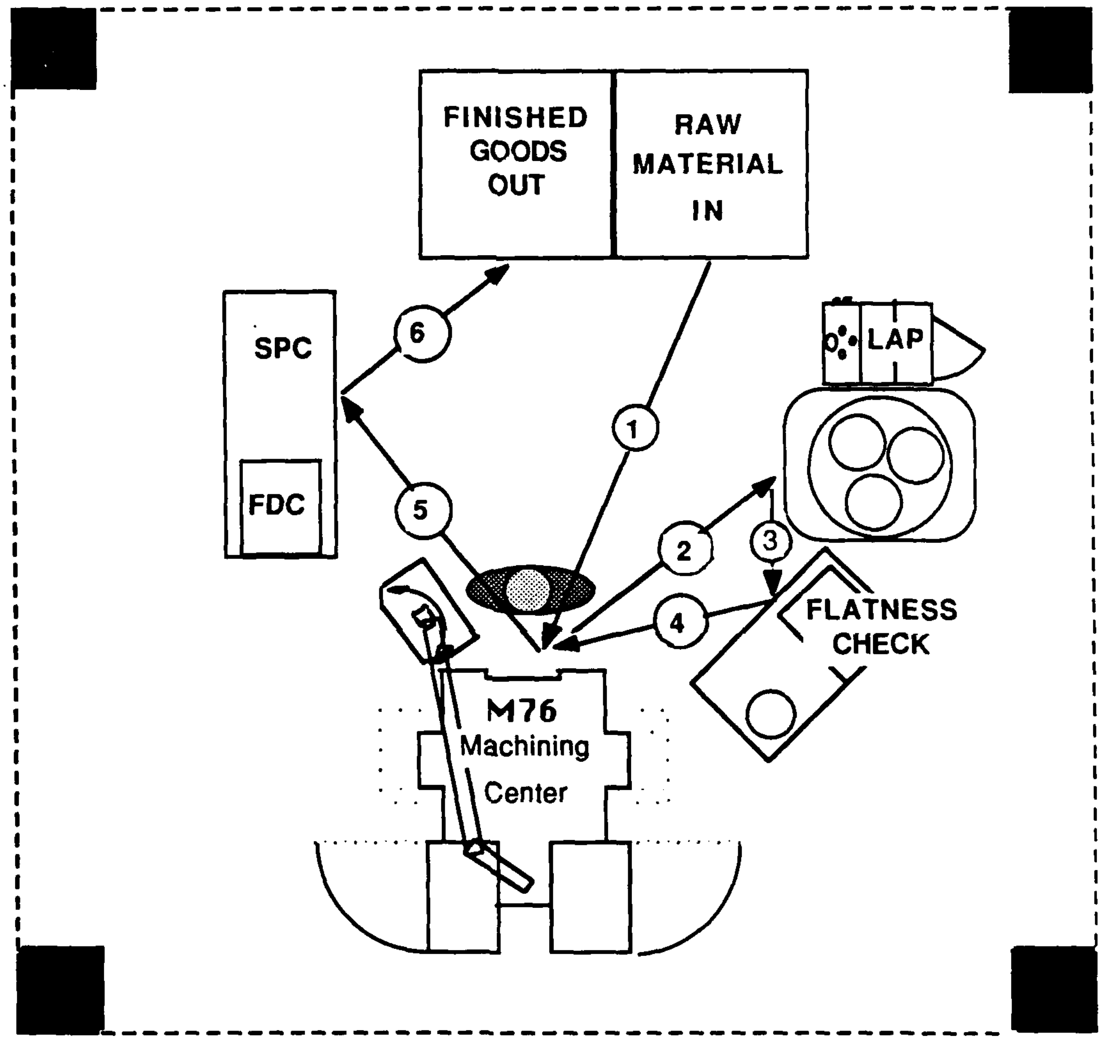
Projected manufacturing volumes were obtained for the laser base and the gyroscope cover by consulting Ring Laser Gyro's Marketing and Assembly Departments. Within these departments, unit sales were given over a ten year period segregated by commercial and military use. To establish the total manufacturing volumes per year, assembly and manufacturing loss factors were added to yearly marketing projections. This gave the forecasted sales volume used to design the Laser Base Cell.

The "As-Is" process for the laser base and gyroscope cover was reviewed by three production engineers. After a thorough analysis of the laser base's manufacturing process, improvements were identified which included eliminating and consolidating machining operations, reducing work-in-process and shortening lead times. By grouping a lap and machining center together and running this equipment with one operator, the elimination of an additional chromate and lapping operation was achieved. The vacuum impregnation system proposed for the Girth Ring Cell will be a shared resource with the Laser Base Cell. This will eliminate all subcontract part travel of vacuum impregnation. These improvements will shorten part travel by over 1000 feet within the shop, eliminate seven in-process stops and shorten lead times to 3 weeks.

A thorough equipment technology search was conducted to determine the best selection of equipment for the Laser Base Cell. For this dedicated cell, the equipment required is one vertical machining center; one lapping machine (new or re-conditioned) and one vacuum impregnation system. Equipment suppliers were identified by the use of Thomas Registers, Honeywell Procurement Department and prior departmental contacts. The suppliers were given part prints and needed machine tool requirements. It was asked that these vendors give time estimates, price quotes and detailed equipment specifications for evaluation. After receiving quotes and data on each piece of equipment, machine selections were made based on price, machining performance and compatibility with current machines in the shop.

A physical layout was developed for this cell, which is shown in Figure 8.1. A 3 axis vertical machining center was selected with a 20 tool station carousal, which allows tools for the laser base and gyroscope cover to be permanently set-up. A lapping machine was positioned adjacent to the milling machine to allow an efficient part flow. This lap is operated internally to the milling machine. The lapping machines purpose is to hold flatness of .001" over 5 mounting surfaces. A 40" high working surface was selected for inputting manufacturing data into a FDC terminal, deburring and electronic gauging. Material will be delivered and removed in 4' X 4' pallets by hand carts.

LASER BASE CELL LAYOUT



MATERIAL FLOW

1. MILL, DRILL, & TAP BOTTOM
2. LAP BOTTOM
3. CHECK BOTTOM FOR FLATNESS
4. MILL DRILL & TAP COMPLETE
5. INSPECT
6. FINISHED GOODS OUT

Figure 8.1 "To-Be" Laser Base Cell Layout

Based on peak forecasted market quantities and "To-Be" standards, utilization of the equipment was established. Within the Laser Base Cell layout, machine utilization for the vertical machining center (M76) is 141 percent. The lapping machine will be run internally to the machining center and its utilization is 31 percent. The utilization of these machines is based on two shifts of operation. From the percent of load, it was found this cell will carry over into the third shift of production.

Tables were developed that represented the distribution of work load by part number within the Laser Base Cell for purposes of cell balancing and direct labor requirements. Cell simulations were calculated by breaking the machining process down into individual work elements. Manpower required to keep this cell in operation is one person per shift and will operate 2.5 shifts.

SECTION 9

SYSTEM/EQUIPMENT/MACHINING SPECIFICATIONS

The Laser Base Cell will consist and be supported by the following equipment.

CNC VERTICAL MACHINING CENTER

- (1) Kitamura - Model Mycenter - 2B

  - Spindle speed range 150 ~10,000 rpm.
  - 20 Tool storage capacity.
  - Spindle orientation.
  - 80 meter tape storage (262 feet).
  - FANUC 11 MA with 14" CRT.
  - Machine dimensions: Length 106" X Depth 73" .

ROTARY TABLE LAP

- (1) Lapmaster Model 24

  - Work Table: 48" X 48".
  - 3 conditioning rings.
  - 24" Serrated lap plate.

SECTION 10

TOOLING SPECIFICATIONS

In the manufacture of the laser base housing and cover, all tooling used is considered perishable. This tooling is procured from outside vendors and is to be discarded when all cutting edges are worn. Geometry of procured tooling must meet production engineering standards which is controlled by the engineering group. All tooling is controlled in a central tool crib in which minimum/maximum stocking conditions are based on shop use.

All fixturing for this cell currently exists in production. For the new fixturing concept, only slight modifications are necessary. These modifications include: the building of a fixture holding plate for quick fixture change; re-location of location pins and bolt holes for mounting to this plate; and the building of one riser plate. With these changes, shortened fixture set-up time was made possible.

SECTION 11

VENDOR/INDUSTRY ANALYSIS/FINDINGS

Throughout the world there are numerous machine tool builders and most of them are represented in the United States. Minneapolis, Milwaukee and Chicago are the major industrial machine tool suppliers of our region and they represent a well rounded cross section of all available equipment. Given this, an industry survey of the region was conducted to identify companies that are capable of supplying equipment that would meet the machine tool requirements of the Laser Base Cell. The selection for potential suppliers was based on the satisfaction of the following criteria (not listed by priority or importance):

- Prior Honeywell - vendor relationships.
- Dunn and Bradstreet status.
- Machine requirements and capabilities.
- On site visits.
- Project support in supplying pertinent data.
- Capability to deliver.
- Price.
- Servicing and training support.

For this dedicated cell, the equipment required is one vertical machining center and one lap (new or re-conditioned). A shared vacuum impregnation system will be done outside of the cell and located within the Metal Finish Area. Equipment suppliers were identified by the use of Thomas Registers, Honeywell Procurement Department and prior departmental contacts. The suppliers were given part prints and needed machine tool requirements. It was asked that these vendors give time estimates, price quotes and detailed equipment specifications for evaluation. After receiving quotes and data on each piece of equipment, a matrix (Figures 11.1 and 11.2) was developed for vendor comparison. This matrix system was used as a quick reference chart to track vendor response to machine tool quotes. Based on the vendor evaluation, the following equipment was chosen.

- VERTICAL MACHINING CENTER

The Kitamura Mycenter 2B was chosen. The equipment is a state-of-the-art 4-axis CNC high precision vertical machining center specifically designed for super close tolerance parts. The machine features a 10,000 RPM spindle for small hole drilling, Fanuc control, programmable spindle orientation, and a 20 tool storage carousal. It has an overall guaranteed accuracy of ± .0001 inch and a repeatability of ± .00004 inch. The machine incorporates the accuracy of a Jig Borer with the productivity of a machining center.

- LAPPING EQUIPMENT

The reconditioned Lapmaster Model 24 was chosen (primarily on price). The Lapmaster was selected to achieve flatness requirements of the laser base. This machine is capable of production lapping to extremely close limits of accuracy and surface finish.

LASER BASE CELL

EQUIPMENT SEARCH FORM
TECH-MOD PROJECT #44

CELL NAME: LASER BASE CELL

PART # IN CONSIDERATION:

HOUSING, LASER BASE
GYROSCOPE COVER

GENERIC EQUIPMENT SPECIFICATIONS:

VERTICAL MACHINING CENTER

EQUIPMENT & VENDOR	INFO SENT	RESPONSE	EQUIPMENT DESCRIPTION	REMARKS
KITAMURA GRANDQUIST CO.	YES	YES	MYCENTER 2B VERTICAL MILLING CENTER	PRICE: $77,500 3-AXIS, 10,000RPM 20 TOOL CARROUSEL
MATSUURA PRODUCTIVITY INC.	YES	YES	MODEL MC-510V VERTICAL MILLING CENTER	PRICE: $96,500 3-AXIS, 20 TOOL CARROUSEL
TAKISAWA HALES MACH.	YES	YES	MODEL MAC-V2E VERTICAL MILLING CENTER	PRICE: $120,500 3-AXIS, 6000 RPM 24 TOOL CARROUSEL

Figure 11.1 Laser Base Vertical Machining Center Vendor Comparison

LASER BASE CELL

EQUIPMENT SEARCH FORM

TECH-MOD PROJECT #44

CELL NAME: LASER BASE CELL

PART # IN CONSIDERATION:

HOUSING, LASER BASE
GYROSCOPE COVER

GENERIC EQUIPMENT SPECIFICATIONS:

LAP (24" TABLE, 3 CONDITIONING RINGS)

EQUIPMENT & VENDOR	INFO SENT	RESPONSE	EQUIPMENT DESCRIPTION	REMARKS
LAPMASTER HARVEY MACH. TOOL	YES	YES	USED MODEL 24 LAPMASTER	PRICE: $6900 (USED)
CLEVELAND FLAT LAP PRODUCTIVITY INC.	YES	YES	MODEL 600 LAPPING MACH.	PRICE: $11950 (24" TABLE)
LAPMASTER JOHN CRANE-HOUDAILLE INC	YES	YES	MODEL 24 LAPMASTER	PRICE: $18,965 (NEW)

Figure 11.2 Laser Base Lapping Machine Vendor Comparison

SECTION 12

EQUIPMENT/MACHINERY ALTERNATIVES

If the primary vendors selected for this cell became unavailable when implementation is scheduled to occur, the following equipment would be purchased:

- Alternative Vertical Machining Center
  - Vendor: Productivity Inc.
  - Model: Matsuura MC-510V

The Matsuura MC-510V was chosen as an alternative for its quick tool changing system, high precision machining capability, small footprint and rigid construction. This machine is equipped with a Yasnac control as opposed to the Fanuc control. Where possible, the Fabrication Facility is standardizing on Fanuc controls throughout the shop for ease in operator training. For this reason the Matsuura MC-510V was not the primary choice.

- Alternative LAP (New)
  - Vendor: Productivity Inc.
  - Model: Cleveland Flat Lap 600

The Cleveland Flat Lap was chosen as an inexpensive alternative to the used Lapmaster Model 24. This machine is to be used internally to the milling operations, therefore a complex lapping machine is not required.

SECTION 13

MIS REQUIREMENTS/IMPROVEMENTS

The Distributed Numerical Control (DNC) programming system will be on-line with the cell's vertical machining center. All operator and engineering changes, program updates and modifications will take place from the programming center. The digitized information will be transferred via a hard wired RS-232 connection. Active programming data will be sorted in hard drive memory which can be directly down loaded to the machining center. This allows complete flexibility in part programming. Reference the NC Programming segment of this final report for further detail on DNC links.

Specific part dimensions will be captured by a Statistical Process Control (SPC) [reference ITM Project 43 Final Report] system within this cell. Electronic gauging will download dimensional readings into the Quality Information System (QIS). From X bar R chart graphical displays, the operator will make machine offset changes based on control limits readings approaching dimensional non-conformance. This stored information will be printed out and will be used for quality control audit purposes.

Honeywell MAvD is in the process of implementing several new systems (HMS, FDC, etc.) that can be utilized by the Laser Base Cell no apparent system modification. For more information on these systems, reference Section 13 of the Project Overview.

SECTION 14

COST BENEFIT ANALYSIS/PROCEDURE

OVERVIEW

The Laser Base Cell is a dedicated cell that will produce only two machined piece parts, which are the gyroscope housing base and the gyroscope housing cover. Both parts are solely used on Honeywell's Laser Glass Gyroscope. The cost driver for this cell was identified using the methodology shown in the process diagram of Figure 14.1.

MANUFACTURING SCHEDULE

The manufacturing schedule for this cell used the marketing plan volume projections by product device. Attrition and part usage per device were accumulated to develop the ten year projections.

ACTUAL STANDARD HOUR SAVINGS

The methodology for deriving the "As-Is" and "To-Be" actual standard hours was followed as described in Section 14 of the Project Overview.

CAPITAL AND EXPENSE

The capital, recurring and non-recurring expense for the Laser Base Cell are shown in Figure 14.2.

PROJECT SAVINGS AND CASH FLOWS

The savings to be realized by this cell exceed Honeywell's Military Avionics Division hurdle rate. The Cell's cash flows are shown in Figure 14.3 with the assumption that capital is available per the implementation plan.

COST BENEFIT ANALYSIS METHODOLOGY

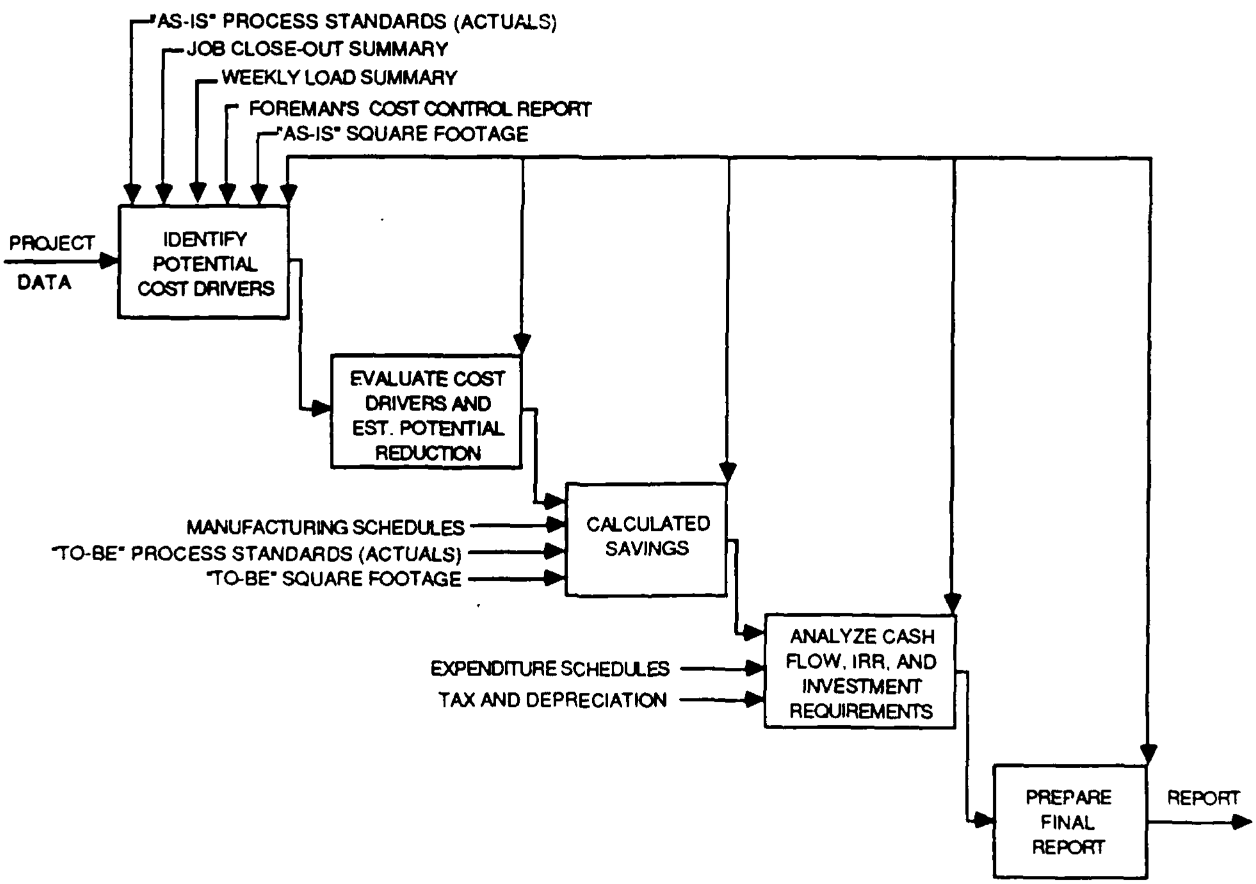


Figure 14.1 Laser Base Cell Cost Benefit Analysis Methodology

LASER BASE CELL
EXPENDITURE SCHEDULE

	Cost	Capitalization Date
CAPITAL COSTS		
MACHINERY COSTS		
Vertical Machining Center	$133,975	1986
Lapping Machine	$9,320	1986
** In-cycle Gauging	$24,116	1988
Tooling (Purchased)	$9,320	1986
Tooling (HI)	$3,495	1986
** Tooling (HI)	$1,474	1988
	$156,110	1986
	$25,589	1988

TOTAL MACHINERY COSTS	$181,699	
FURNITURE COSTS		
** Work Table / Tool Storage	$2,010	1988

TOTAL FURNITURE COSTS	$2,010	1988
	$156,110	1986
	$27,599	1988

TOTAL CAPITAL COSTS	$183,709	
EXPENSE COSTS		
NON-RECURRING EXPENSES		
Area Preparation Labor (HI)	$8,000	1986
Area Preparation Labor (HI)	$5,000	1988
Training (HI)	$2,000	1986
Process Development Direct Labor	$4,000	1986
Post Processor Development Labor	$2,000	1988
	$14,000	1986
	$7,000	1988

TOTAL NON-RECURRING COSTS	$21,000	

TOTAL CAPITAL + NON-RECURRING	$204,709	
RECURRING EXPENSES		
* Annual Maintenance (Mechanical)	$2,000	
* Annual Maintenance (SW & HW)	$583	

TOTAL RECURRING	$2,583	

* Expense starts in year 2.
** Costs contain a 15% contingency

Figure 14.2 Laser Base Cell Expenditure Schedule

TECH MOD PHASE 2

PROJECT 44 – LASER BASE CELL

PROJECT CASH FLOW SUMMARY
($000)

	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	TOTAL
Capital	$156.1	$0.0	$27.6	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	$183.7
Non-Recurring Expenses	$14.0	$0.0	$7.0	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	$21.0
Recurring Expenses	$0.0	$0.0	$2.2	$2.6	$2.6	$2.6	$2.6	$2.6	$2.6	[illegible]2.6	$2.6	$22.9
Total Savings	$0.0	$118.2	$146.6	$223.3	$203.7	$177.1	$145.0	$131.3	$145.5	$13[illegible]	$134.6	$1.557.9
Depreciation	$15.6	$28.1	$25.1	$22.8	$18.2	$14.6	$11.7	$12.6	$12.2	$12.[illegible]	$10.3	$183.7

Figure 14.3 Laser Base Cell Cash Flows

SECTION 15

IMPLEMENTATION PLAN

The final implementation of this cell is unique in that capital investment and procurement of machines took place in the first half of 1986. The present arrangement of these machines currently do not conform to the final Laser Base Cell design. The initial arrangement of the machines and gauging equipment was for the manufacture of three parts. The laser base and cover were among those three, so consequently the cellular design is very similar.

The implementation of the Laser Base Cell will be achieved by a secondary rearrangement. Figure 15.1 shows the implementation schedule for this time period. The rearrangement will occur the third quarter of 1988 and will be implemented in parallel with the Pallet Cell. The Laser Base Cell will be fully operational by the end of the third quarter of 1988. This includes all interfaces with the various manufacturing information systems including the DNC link.

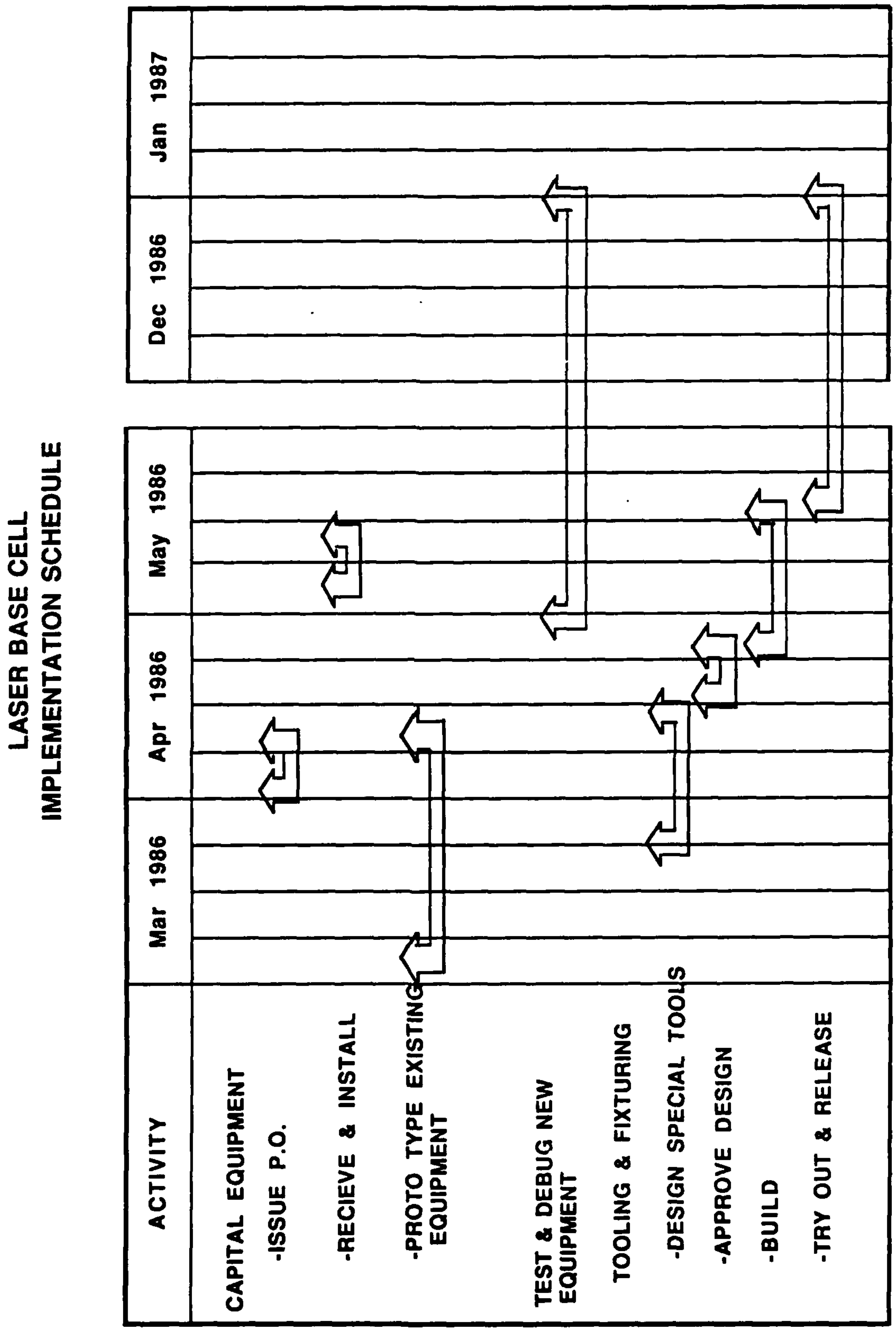


Figure 15.1 Laser Base Cell Implementation Schedule

SECTION 16

PROBLEMS ENCOUNTERED AND HOW RESOLVED

Problem: When switching production orders from the laser base housing to the gyroscope cover, a complete tooling/fixturing tear down was necessary.

Resolution: Tooling was analyzed and it was found that the laser base and the gyroscope cover could be manufactured with the same tooling. An offset matrix was developed for assigning tool offsets for each part. Reprocessing and programming achieved zero tool holder set-up time. The fixturing was then analyzed for quick set-up. It was found that a fixture plate with common mounting patterns would permit quick and accurate fixture set-up. Fixture location pins were then re-worked to match the mounting plate. The result was an accurate set-up with minimal down time.

Problem: For the laser base housing, a subcontract vacuum impregnation operation was needed. This caused an unacceptable increase in the manufacturing lead time.

Resolution: An in-house vacuum impregnation system was found to be feasible. With this in-house process, lead times can be reduced by two weeks.

SECTION 17

AREAS FOR FUTURE CONCERNS/DEVELOPMENT

FUTURE CONCERNS

If production volumes of the laser base housing and gyroscope cover exceed the capacity of this cell, an additional CNC vertical machining center will be procured. The manpower requirement of this enhanced cell will remain at one.

If production volumes decrease and excess machine capacity is available, only selected parts that have common machining characteristics may be added. Fixtures must have location pins that will mount on the existing base plate. Fixture size must not exceed the cells base plate machining envelope. The integrity of common tooling must not be altered by the addition of new parts. By doing so, down time will be kept to a minimum.

FUTURE DEVELOPMENTS

The Laser Base Cell is integrated into the Pallet Cell for reasons of material flow and machining similarities. After aluminum parts are machined and awaiting chromate, it is proposed these parts travel to an automated chromate line in small batches. This chromate line would be isolated in an enclosed room within the Pallet/Laser Base Cell area. This line must also be located adjacent to the Metal Finish Department where chemical storage, waste treatment and manpower may be shared. The main purpose of this chromate line is to chemically treat aluminum parts (die cast, solid and sheetmetal) cost effectively in small batches. Its location allows very efficient post metal finish material flow through vacuum impregnation, heli coil insertion and final audit. By linking the chromate line to the Pallet Cell, this area becomes a complete manufacturing cell with the flexibility to produce low - high volume product from raw material into finished goods.

Some potential problems, and the way they could be handled are listed below:

1. Strong acids are located close to the machines. Several methods would be used to minimize this hazard:

   a) Castings would be purchased already pickled to entirely eliminate two acids from the process.

   b) Two room temperature acids are needed in the chromate machine, but they would be vented to meet EPA standards, and the machine would be enclosed by a partition wall to control air movement.

   c) A second exhaust system using an alternate source of power would be included to maintain a negative pressure at the machine if the primary power fails.

2. A great variety of sizes and shapes of parts are involved which complicates the rinsing and draining of the parts. A universal rack is not deemed feasible, so a number of rack designs would be needed, some specific to individual parts and some specific to a general size and shape of the part. Racks would be hand loaded by an operator. Spray rinsing would be incorporated at some rinse stations.

3. Acids and chromate chemicals are regulated for sewer introduction. For chrome, a dragout rinse is included, and that rinse plus any batch dumps would be transferred by permanent pipe to the waste treatment area of the plating shop. Acids would be water jet aspirated through a permanent pipe to the same waste treatment area.

4. Two classes of chromate (1a and 3) are used on our parts. It is possible and quite common to draw both classes from the same process by using a proprietary chromate chemical that is approved for both classes.

The automatic chromate line would be made up of 12 process tanks, a load station, an unload station and a dry station. The process tanks would include one solvent degrease, one flash off, one alkaline clean, two acids, one chromate, five rinse and one hot deionized water spray. The rack transport would be by means of a single hoist traversing a straight line track in the method commonly used by the plating industry. The rack transport is computer controlled, with storage capability for eight process cycles.

It is projected that this machine will fit in an area 20 X 46 feet with the length of the machine, including load, dry and unload stations, dictating the shape of the area. It is further projected that the optimum arrangement would have a dry station off of the automatic machine, with a means of transporting racks to a separate conveyorized dry unit that moves racks to an unload station and permits some stacking of racks.

These concepts have been discussed and will be investigated in detail when the cell has been installed. The benefits derived from this system would mean significant reductions in labor costs and improvements in material flow.

PROJECT 44

WALNUT CELL

SECTION I

INTRODUCTION

Walnut is the name given to the motor housing used in the GNAT and GG4400 series gyros. It is manufactured in the Fabrication Facility (Fab Fac) complete, and delivered to the Precision Control Instruments (PCI) area as two matched machined halves. The halves are made from 1 1/4 inch diameter aluminum stock machined to precision tolerances as close as ± .0002 inch on the journal diameters. The walnut is a thin walled housing approximite 7/8 inch in diameter consisting of two disc shaped halves that snap fit together to form the housing assembly. Due to the high number of separate manufacturing operations currently used to make the part, it has a long lead time for new orders. This combined will a large volume (greater than 25,000/year) makes the Walnut a logical choice for grouping its manufacturing operations into a dedicated "Walnut Cell".

The cell formation was approached in two phases. Phase I used a "Low-Tech" approach and involved the refining of the "As-Is" processes and rearranging of the present equipment. Phase II used a "High-Tech" approach and introduced CNC technology and new processes to produce the motor housings.

SECTION 2

PROJECT PURPOSE/OVERVIEW

The primary objectives of the "Walnut Cell" are to reduce cost while maintaining high quality in the finished part. This can be done by reducing lead times, minimizing Work-In-Process inventory, improving material handling, and by offering flexibility to demands.

To achieve these objectives, efforts were concentrated in establishing a cellular manufacturing environment, applying better manufacturing methods through CNC technology, and reprocessing the operations. This resulted in a "Just in Time" and "Pull" manufacturing environment with substantially improved productivity and reduced cost. The cellular approach also improved material flow by establishing positive material control at all times, and providing continuous operations for better process control and quality assurance. Large reductions in lead times increased the shops flexibility to respond to customer demands.

SECTION 3

TECHNICAL APPROACH

The approach taken to complete the Walnut Cell project followed these steps:

1) Identify all the present processes; study and understand each operation performed to produce the Walnuts.
2) Study the cycle time of each operation.
3) Study, analyze and understand the tooling and fixturing used in each operation.
4) Establish the material flow throughout the shop. Determine the work-in-process locations and approximate duration of queuing.
5) Prepare the As-Is process flow diagram.
6) Investigate order quantities and lead times.
7) Observe the quality control operations.
8) Study and understand production problems.
9) Rearrange the manufacturing resources into one area for better material flow.
10) Eliminate repetitive operations.
11) Design a special drill and ream fixture to reduce the cycle time of a bottleneck operation and integrate the reduced time elements with another suitable operation.
12) Prepare a process flow diagram.

After completing the above tasks, a thorough understanding of the present operations was provided. In addition to the tasks performed on the shop floor, production engineers were interviewed about the background and history of certain processes The data gathered helped to identify the areas needing improvement.

It was concluded that a cellular approach could be taken to manufacture the Walnuts by addressing the following issues:

- Manufacturing cost.
- Tooling and fixturing.

- Material handling and material control.
- Lead times.
- Quality.

The first attempt at forming a dedicated Walnut Cell established the frame work of the cell and was called the Preliminary Design. It is also referred to as the "Low-Tech" Approach or Phase I. The Preliminary Design offered unique opportunities for further improvements. Currently the Walnuts are being produced starting with an extruded aluminum shell as material. A thorough analysis of the extruded shell and the operations performed to obtain the final part configuration triggered the idea of producing the Walnuts from a solid aluminum bar by utilizing modern CNC machining technology. This approach, referred to as the "High-Tech" approach or Phase II, offered substantial cost reductions due to the elimination of multiple operations necessary on the extruded shell. In a single CNC Lathe cycle in combination with a chore operation, the final Walnut configuration can be reached. This second approach delivered the maximum benefits and was selected as the "Final Design" of the cell.

SECTION 4

"AS-IS" FROCESS

INTRODUCTION

The "As-Is" conditions for the Fabrication Facility (Fab Fac) in general are detailed in Section 4 of the Project Overview. This section details only those items that are unique or specific to the parts group mentioned below.

The Walnut is the motor housing used in the GNAT and GG4400 series gyros. After the Walnut is complete and delivered to the Precision Control Instruments (PCI) assembly area as two matched machine halves, a stator and gyroscopic rotor will be installed inside the Walnut and sealed. The Walnut is machined to very precise tolerances. The precision necessary is currently achieved using conventional machining methods that require multiple operations performed on several different machines. To have a good understanding of the "As-Is" process, the following topics will be discussed:

- Production Control
- Manufacturing cost
- Material handling and material control
- Lead time
- Work-in-process inventory
- Direct labor utilization
- Quality

PRODUCTION CONTROL

The production control of orders is triggered by the receipt of a traveling requisition accompanied by a process summary, layout and prints. Facilitators of the production control department include the inventory card file, computer hardware and software, clerical and data personnel, production planners and planning boards.

Production Control issues shop packets and planner priority lists to control production on the floor. It is a completely manual operation once issued. To push priority parts through the shop, it is necessary to have production control people follow the parts from operation to operation. The parts travel through the shop supporting traditional manufacturing philosophies. Figure 4.1 shows the "As-Is" Walnut material flow through Fab Fac.

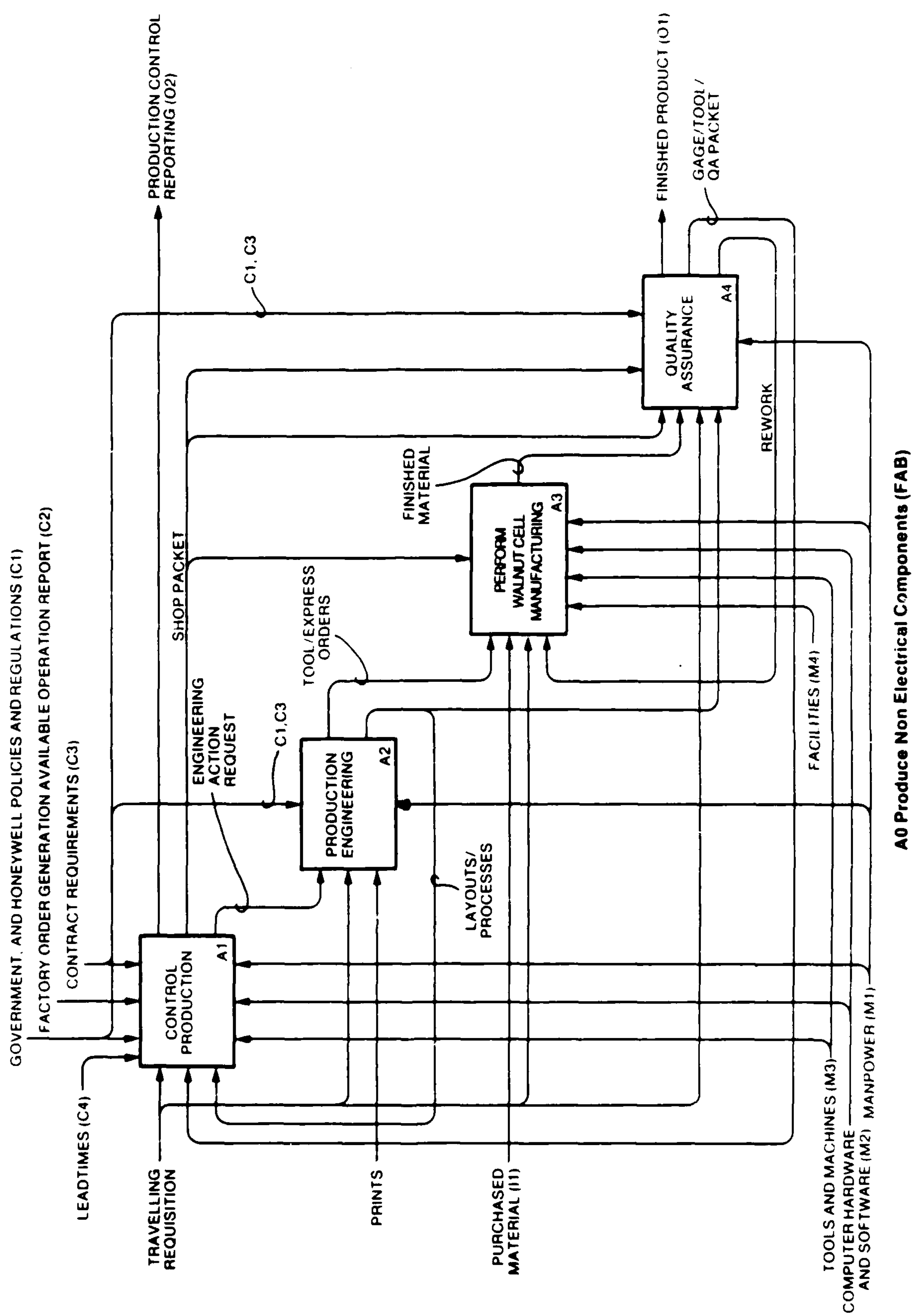


Figure 4.1 "As-Is" Walnut Workflow Diagram

MANUFACTURING COSTS

The current manufacturing processes and methods are not the most cost effective way of producing the Walnuts. The equipment used are of conventional type and primarily manually controlled. This sets the pace from the beginning to the end, and dictates the type and form of the fixtures and tools to be utilized. It also makes necessary a large number of operations to be performed to achieve the final part configuration. Each operation adds value to the part, increasing the manufacturing cost. The history of the parts manufacture shows that throughout the years as new processes were integrated many of the old unnecessary processes were not phased out making the cost even worse. Figure 4.2 shows the sequential "As-Is" process flow diagram.

MATERIAL HANDLING AND MATERIAL CONTROL

As the present material flow path is followed, all of the operations shown on the sequential process flow diagram (Figure 4.2) are done independently at machines and locations spread throughout the shop (Figure 4.3). Currently each part travels approximately 2,640 feet through the shop and makes 24 stops.

Because the equipment used is not dedicated to Walnut production, their locations are not related to any kind of efficient material flow plan. This creates very undesirable material flow conditions, causes difficulties in material control and contributes to high scrap and rework.

LEAD TIME

As mentioned above, traveling long distances and having a large number of intermediate stops means the parts are being queued at each location having to wait for their turn before the next operation. At each of these locations they may be forgotten, lost or left waiting a very long time. This often results in very long lead times.

WORK-IN-PROCESS INVENTORY

The long lead times result in excessive WIP inventory and prevents accurate new order release quantities. On average, there are seven separate orders at various locations throughout the shop.

DIRECT LABOR UTILIZATION

Due to the scattered pattern of all the manufacturing operations, the direct labor utilization is very inefficient. At present, there is no work load balancing system to maximize the direct labor utilization.

QUALITY

Current processes, tooling, fixturing, workflow, and long lead times are not contributing to good quality. Scrap and rework are at unacceptable levels. The extruded aluminum shells used as raw material are not always to print which causes deviations requiring extra operations, or rejections due to irreparable problems. Long time exposure to the humid atmosphere corrodes the copper plated parts resulting in previously good parts being rejected in assembly.

WALNUT CELL FLOW DIAGRAM -- AS IS

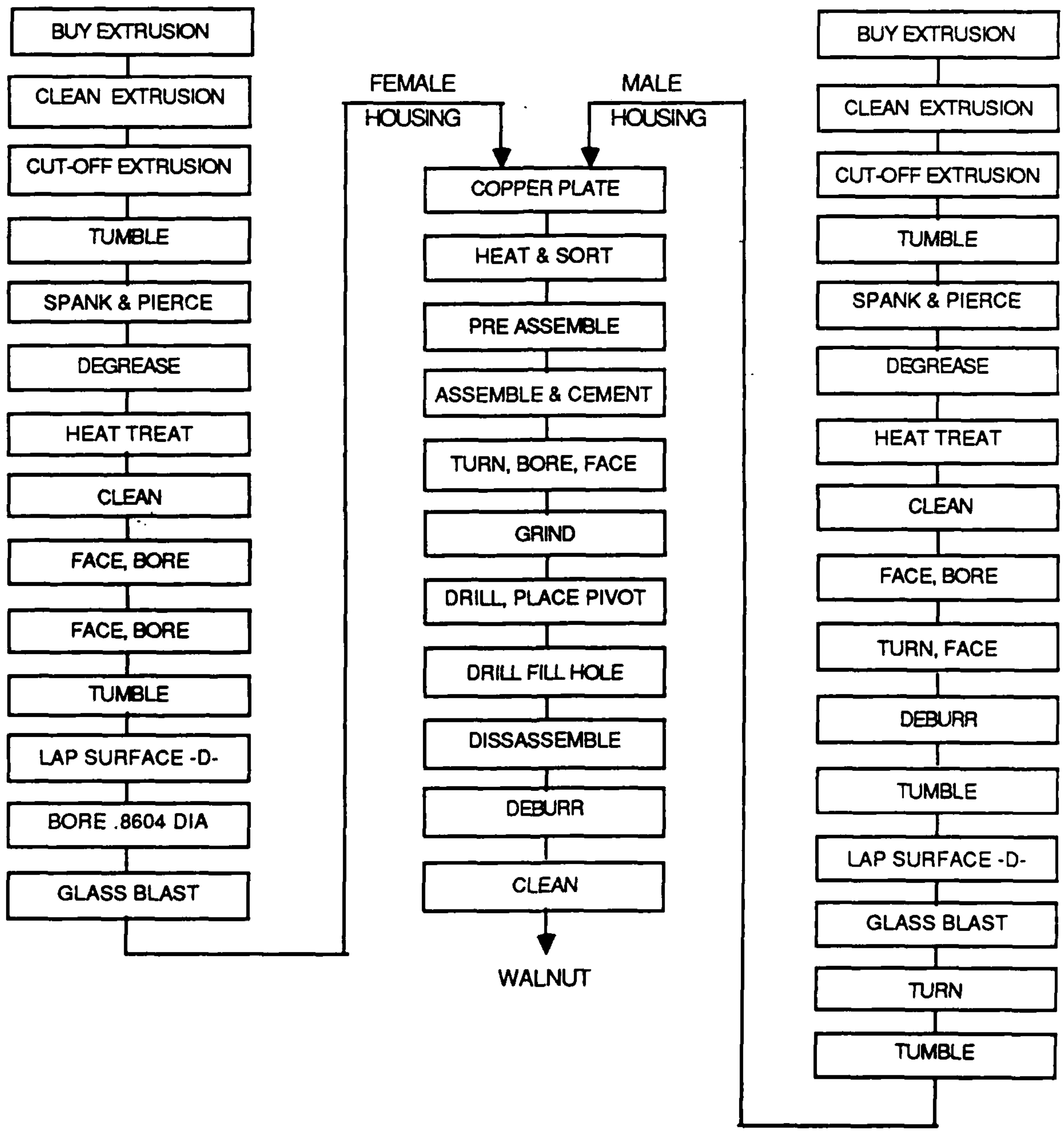
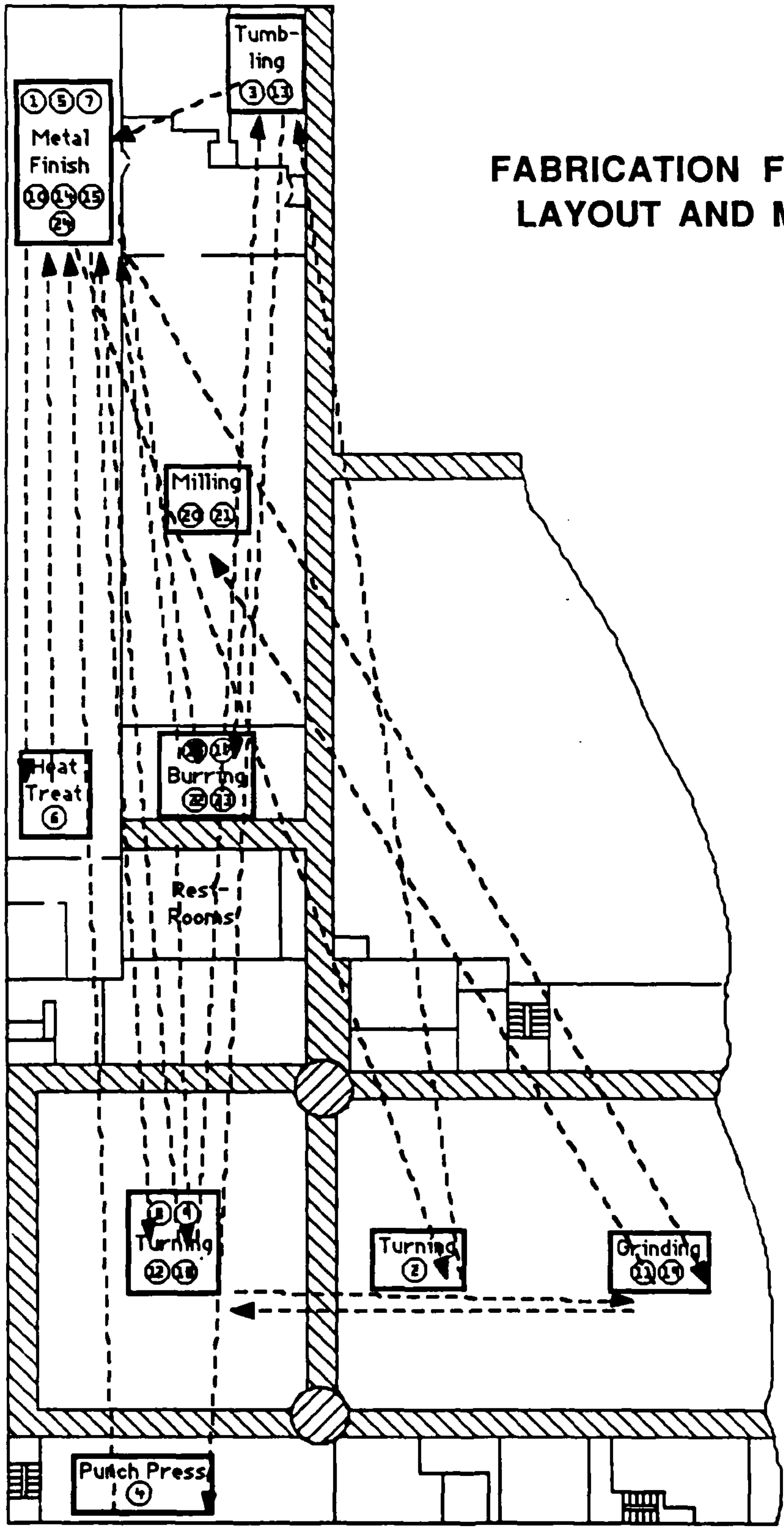


Figure 4.2 "As-Is" Walnut Process Flow Diagram



FABRICATION FACILITY -- AS IS LAYOUT AND MATERIAL FLOW

Figure 4.3 "As-Is" Walnut Material Flow and Facility Layout

SECTION 5

"TO-BE" PROCESS

INTRODUCTION

The "To-Be" conditions for the Fabrication Facility (Fab Fac) in general are detailed in Section 5 of the Project Overview. This section details only those items that are unique or specific to the parts group mentioned below.

By utilizing CNC technology and other modern manufacturing methods and devices, the final "To-Be" process has become a much less involved procedure. Lead time and work-in-process inventory have been drastically reduced. The production control activities have been made more efficient through the use of a computerized production control system. Labor hours have been decreased and the quality has been improved as a result of the reduced number and complexity of the operations now performed. All of these changes have added up to greatly reduced product cost.

The "To-Be" process was established in two phases. A detailed description and identification of these two phases is given in Section 3 of this report. In both phases, the following issues were the main drivers:

- Production Control
- Manufacturing Cost
- Material Handling and Material Control
- Lead Time
- Work-In-Process Inventory
- Direct Labor Utilization
- Facility
- Quality

PRODUCTION CONTROL

The production control activities in the Walnut Cell will be performed with the aid of a computerized, integrated manufacturing system called HMS (Honeywell Manufacturing System). This system is described in detailed in Section 5 of the Project Overview.

MANUFACTURING COST

Rearranging the manufacturing resources utilized to produce the Walnut in the Phase I design resulted in the elimination of some unnecessary, repetitive operations, and greatly reduced travel distance. After establishing the preliminary Walnut Cell design parameters, opportunities for further improvements were identified and a new approach was taken to produce the Walnut Halves from solid aluminum bar in the Phase II design. The number of operations was greatly reduced by utilizing CNC Machining Technology. The tooling and fixturing were simplified to increase precision and decrease scrap. The final design will bring about a 68% reduction in manufacturing costs. Refer to Figure 5.1 for the "To-Be" workflow diagram and Figure 5.2 for the "To-Be" process.

MATERIAL HANDLING AND MATERIAL CONTROL

Material handling and control is greatly improved with the formation of the dedicated cell. All the operations with the exception of copper plating will be performed in the cell area of 470 square feet. The parts will travel a total of 250 feet compared to the present 2,640 feet. Refer to Figure 5.3 for the "To-Be" material flow. Cell formation simplifies the material control activities and offers the required flexibility.

LEAD TIME

Due to improved material handling, control and the "To-Be" production control system, the present lead times of 244 days are drastically reduced to 4 days making the cell flexible to customer demands.

DIRECT LABOR UTILIZATION

Cell formation makes it possible to balance the operations to uniformly divide the work load amongst the operators. This increases the direct labor utilization while minimizing the direct labor count.

FACILITY

Presently the Walnuts are utilizing a large area of the shop. The final design requires a space of only 470 square feet (Figure 5.3). This is due to the cellular manufacturing concept adopted that localized the operations in one area.

QUALITY

Due to the positive effects discussed above, improvement in the quality of the Walnuts is expected. The cell operators will be responsible for the entire process with the exception of the copper plating operation, and will be gauging there own work. The reduction of the number of machining operations by the use of CNC technology assures dimensional and configurational integrity, as well as reputability.

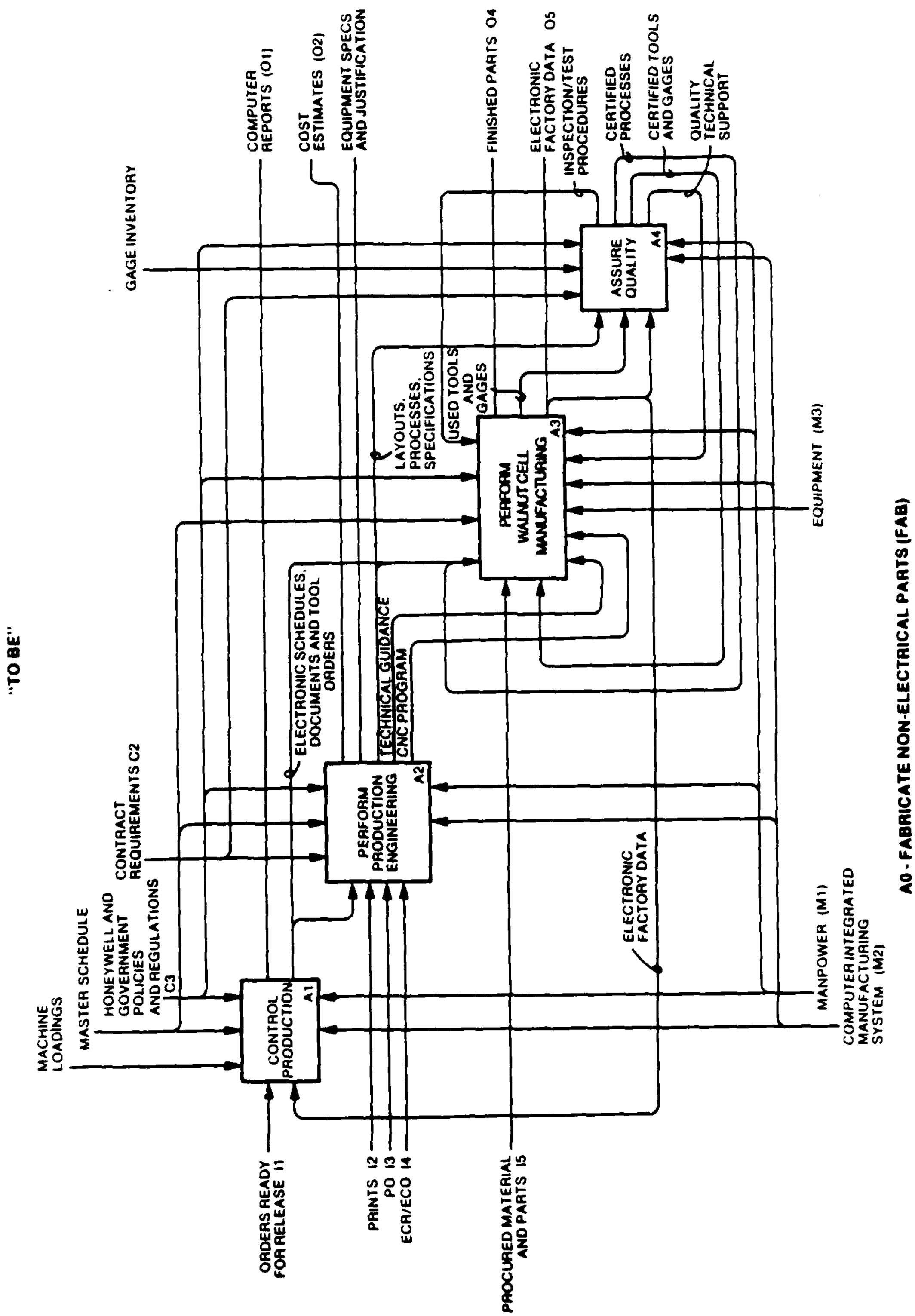


Figure 5.1 "To-Be" Walnut Workflow Diagram

WALNUT PROCESS FLOW DIAGRAM -- PHASE II

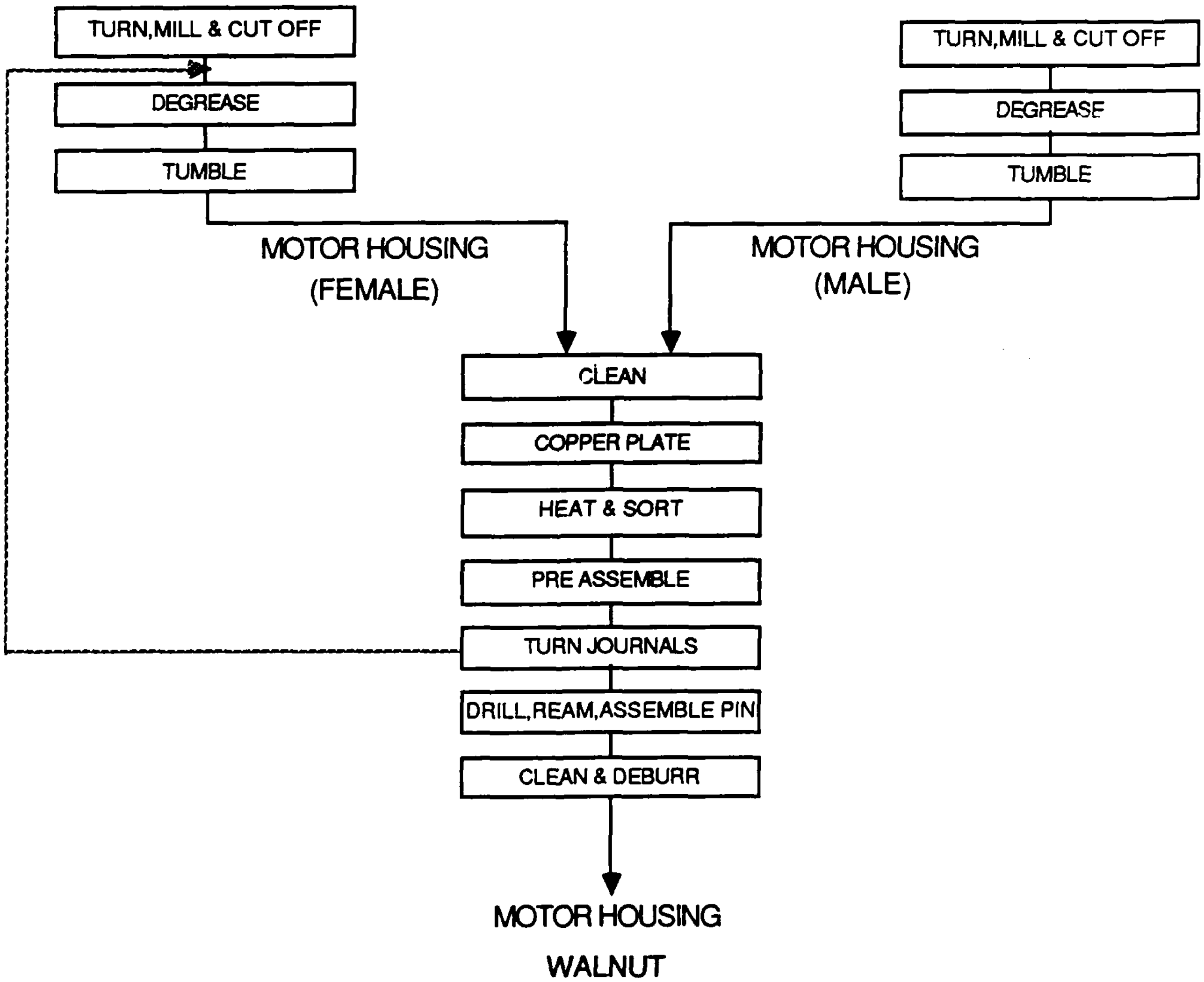
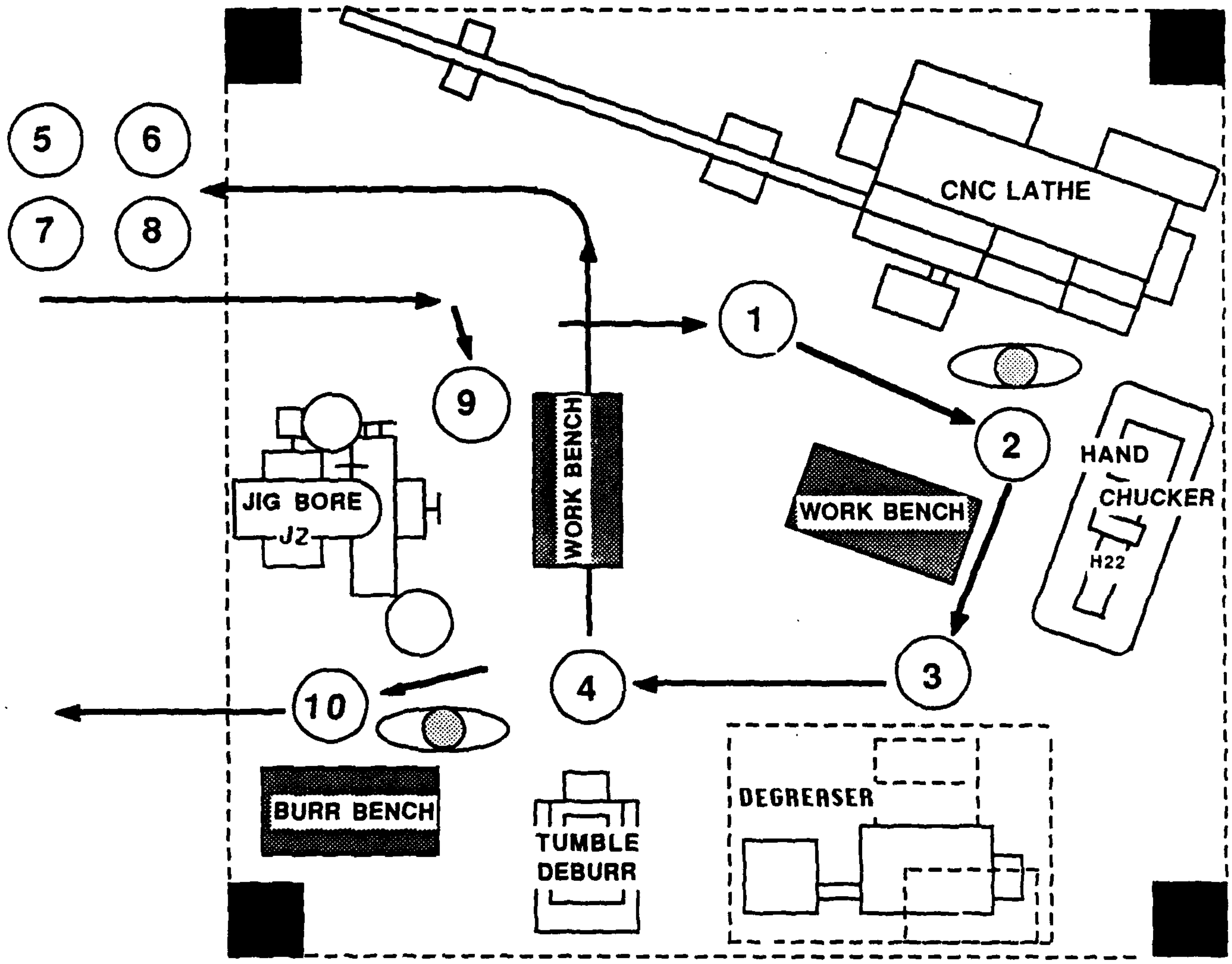


Figure 5.2 "To-Be" Walnut Process Flow Diagram (Phase II)

WALNUT CELL LAYOUT (PHASE II)



1. TURN, MILL & CUT-OFF	6. COPPER PLATE
2. TURN JOURNALS	7. HEAT & SORT
3. DEGREASE	8. PRE-ASSEMBLE
4. TUMBLE	9. DRILL, REAM & ASSEMBLE PIN
5. CLEAN	10. CLEAN & DEBURR

TOTAL AREA 470 SQ.FT.

Figure 5.3 "To-Be" Walnut Material Flow and Facility Layout (Phase II)

SECTION 6

PROJECT ASSUMPTIONS

In order to carry out and bring this project to a conclusion certain assumptions had to be made. These assumptions were:

- The Production requirements will be met by a 2 shift operation.
- One shift operation will be based on 1700 hours per year with an estimated shop performance of 85%.
- The floor space and capital identified will be made available at the time of implementation.
- Labor classification changes in this portion of Project 44 are not limited by the present bargaining unit contract.

SECTION 7

GROUP TECHNOLOGY CODING SYSTEM ANALYSIS

The Walnut Cell was formed as a result of the group technology technique used to identify viable manufacturing cells. Section 7 of the Project Overview covers this process.

SECTION 8

PRELIMINARY/FINAL DESIGN AND FINDINGS

The final Walnut Cell concept was achieved in two phases. The preliminary or Phase I design (low tech approach) was the initial attempt at simplifying and shortening material flow paths, and optimizing current operations. Figure 8.1 shows the Walnut Cell preliminary design layout. This layout is the synthesis of the initial studies findings combined with the rearrangement of the equipment into one area.

The material flow and operations through the cell can be followed by using the process flow diagram in Figure 8.2. This shows that the male and female halves are handled separately up to the operation where they are paired and continue being processed as a matched set. Comparing Figures 8.2 and 8.3, the Phase I process flow diagram shows the decrease in the number of operations performed.

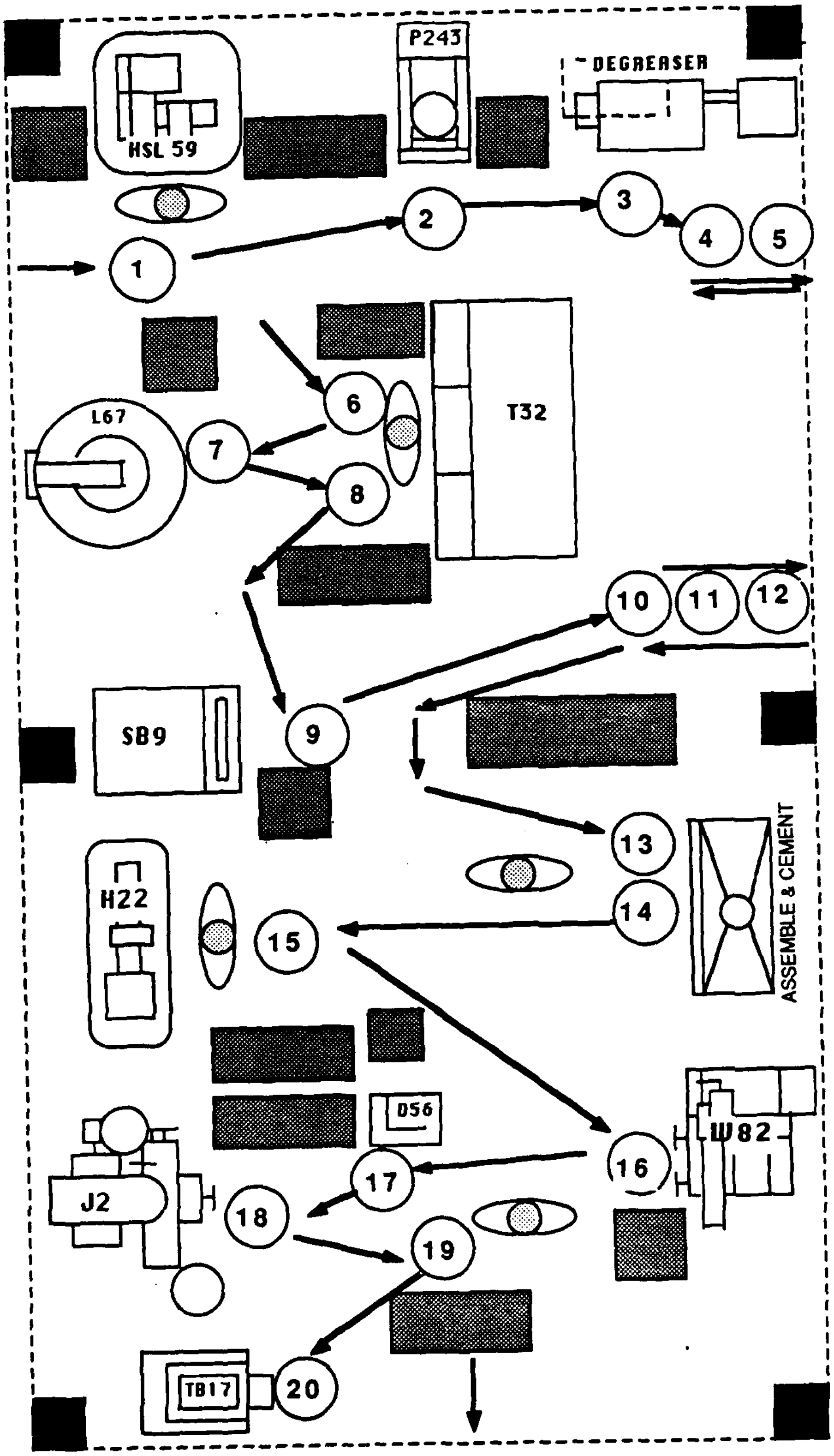
A cell loading matrix was prepared to show the work load in the Phase I Walnut Cell (Figure 8.4). The equipment utilization section shows where the bottleneck operations are located. The maximum cell output was determined from this data.

Cell formation offers the opportunity for better utilization of direct labor. A reasonable work balance was obtained by grouping the operations to define manpower requirements.

From the results of the preliminary design, it became apparent that the nine operations performed to bring the Walnut's extruded aluminum shell to its final shape (see Figure 8.2). could be improved. Modern machining technology allows a new approach to be taken. A CNC lathe equipped with live tooling can machine a walnut half from solid bar stock. It takes a single set-up and one machine cycle to complete a Walnut half, compared to the nine operations necessary in the Phase I design layout. This resulted in a drastic 68% reduction in manufacturing costs and is the basis for the final Phase II design.

To facilitate the machining of the Walnut halves using the CNC lathe, some design changes were directed to the design engineers responsible for the Walnut. After analyzing the suggested changes, they concurred and generated new part prints. These prints will be used to make sample parts on a CNC lathe with live tooling for engineering evaluation.

The final design (Phase II) increased the cell capacity due to the shortened cycle time of the bottleneck operation in the cell. The final layout of the Walnut Cell (Figure 8.5) shows the simplicity in material flow. Figure 8.6 gives the corresponding process flow diagram clarifying the operation sequence in and out of the Walnut Cell. After implementation, the Walnut Cell will utilize 50% of the "As-Is" floor space.



1.CUT OFF EXTRUSION
2.SPANK & PIERCE
3.DEGREASE
4.HEAT TREAT
5.CLEAN
6.FACE,BORE
7.LAP SURFACE -D-
8.TURN, FACE
9.GLASS BLAST
10.CLEAN
11.COPPER PLATE
12.HEAT & SORT
13.PRE ASSEMBLE
14.ASSEMBLE & CEMENT
15.TURN,FACE
16.GRIND
17.DRILL FILL HOLE, BORE
18.DRILL, ASSEMBLE PIN
19.DISASSEMBLE
20.CLEAN & DEBURR

TOTAL AREA
900 SQ. FT.

Figure 8.1 Preliminary Walnut Cell Layout (Phase I)

WALNUT CELL PROCESS FLOW -- PHASE 1

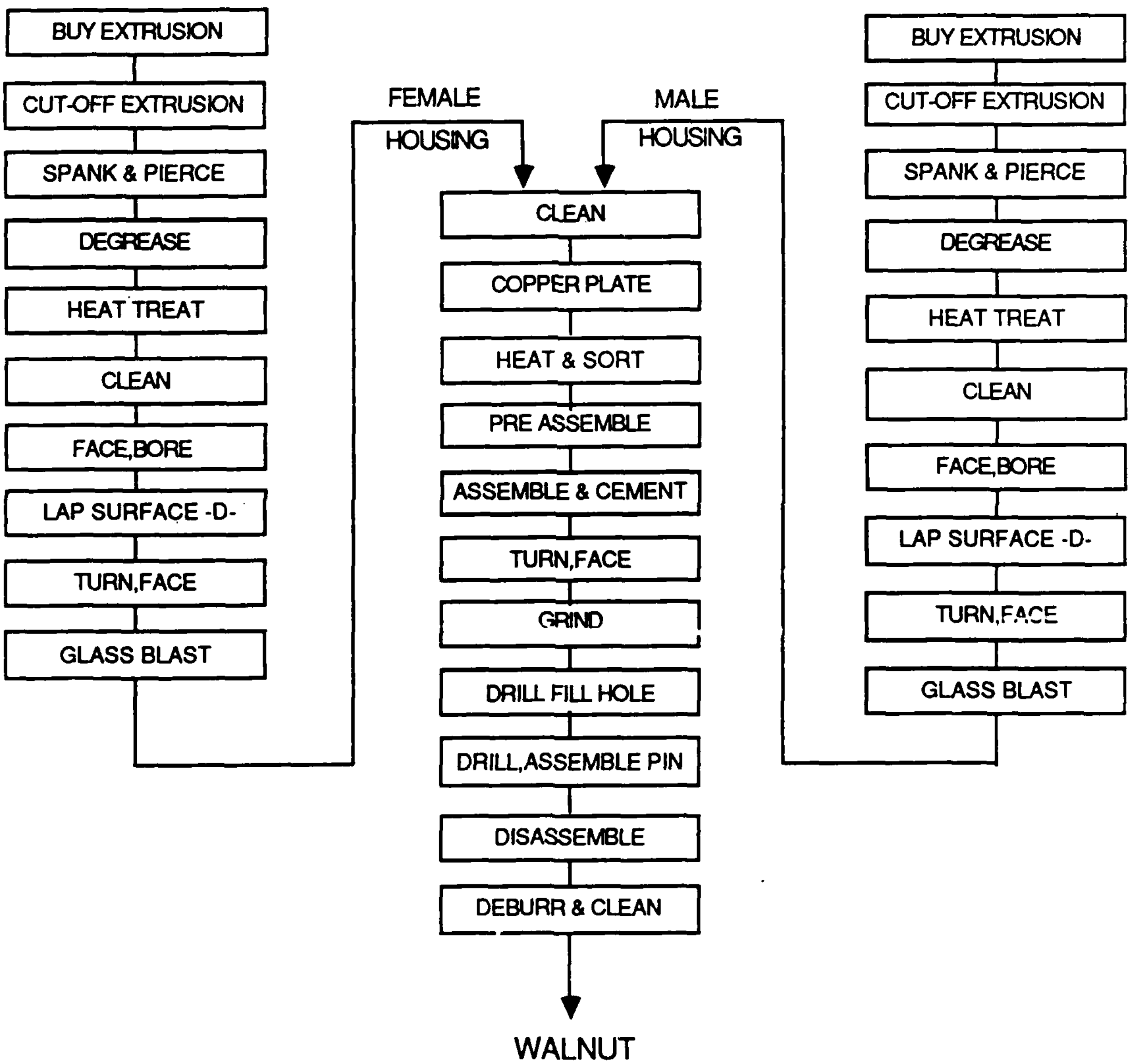


Figure 8.2 Preliminary Walnut Process Flow Diagram (Phase I)

WALNUT CELL PROCESS FLOW DIAGRAM – AS IS

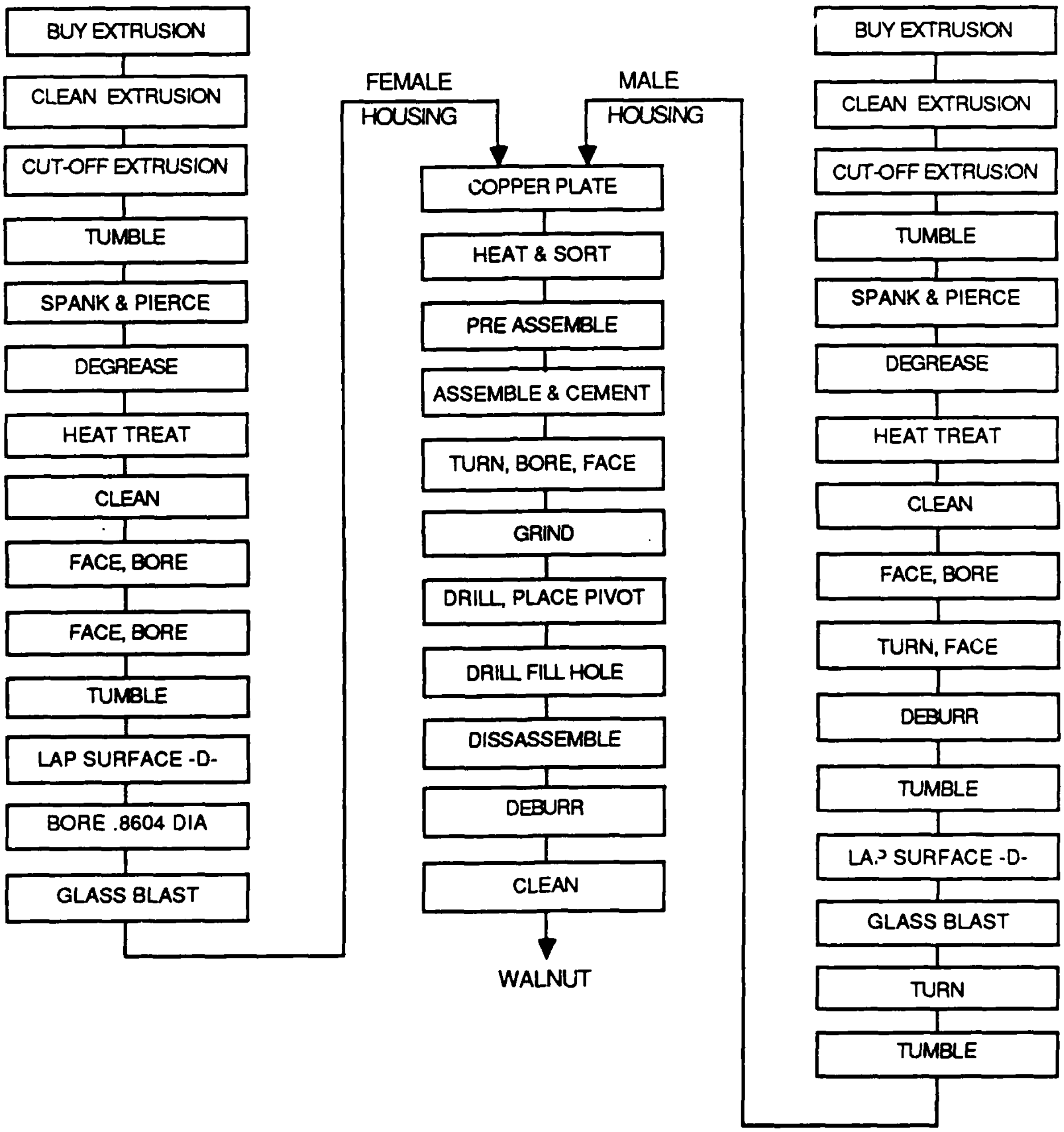


Figure 8.3 "As-Is" Walnut Process Flow Diagram

WALNUT CELL LOAD -- PHASE I

		T32		T28		T22		L67		G82		P243		J2		DRILL PRESS		GLASS BLAST		ASSY & CEMENT	
PART NUMBER	QTY	HRS/PC	TOTAL	HRS/PC	TOTAL	HRS/PC	TOTAL	HRS/PC	TOTAL	HRS/PC	TOTAL	HRS/PC	TOTAL	HRS/PC	TOTAL	HRS/PC	TOTAL	HRS/PC	TOTAL	HRS/PC	TOTAL
462-1	16,000	0.0531	849.60	0.007	112.00			0.015	240.00			0.004	64.00					0.011	168.00		
463-1	16,000	0.054	864.00	0.01	160.00			0.015	240.00			0.004	64.00					0.008	120.00		
465-1	480					0.125	60.00			0.188	90.24			0.033	15.84	0.035	16.66			0.047	22.56
465-3	2,880					0.125	360.00							0.033	95.04	0.035	99.94			0.047	135.36
465-4	800					0.125	100.00			0.188	150.40			0.033	26.40	0.035	27.76			0.047	37.60
465-5	11,840					0.125	1480.00			0.188	2225.92			0.033	390.72	0.035	410.85			0.047	556.48
		TOTAL	1713.60		272.00		2000.00		480.00		2466.56		128.00		528.00		555.20		288.00		752.00

EQUIPMENT UTILIZATION

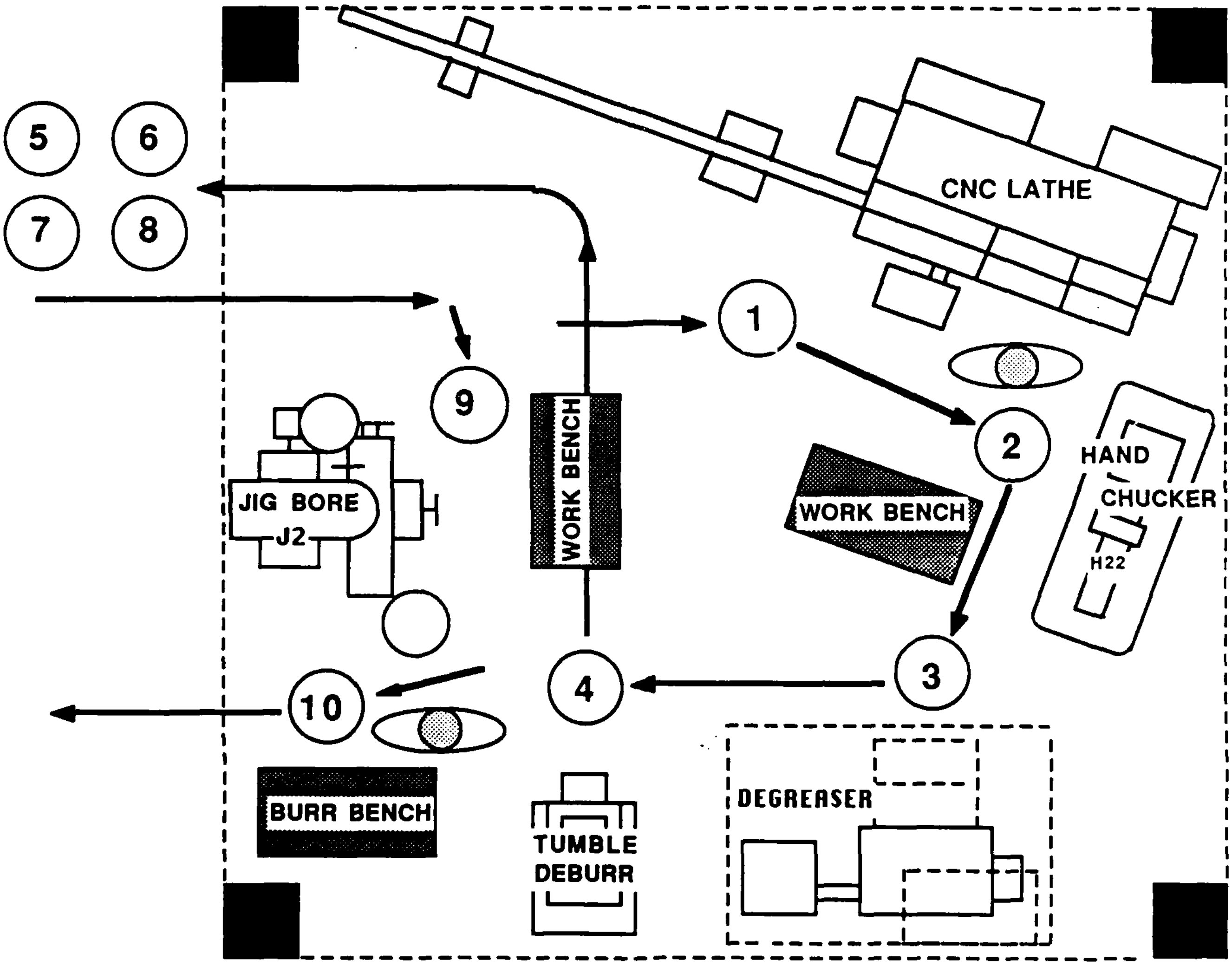
EQUIPMENT TYPE				% OF LOAD
T32				55.69%
T28				8.84%
T22				65.00%
L67				15.60%
G82				80.16%
P243				4.16%
J2				17.16%
DRILL PRESS				18.04%
GLASS BLAST				9.36%
ASSY, CEMENT				24.44%

CELL LOADING

BASED ON THE FORCASTED QUANTITIES AND "TO-BE" STANDARDS, UTILIZATION OF EQUIPMENT WAS ESTABLISHED. BY IDENTIFYING THE BOTTLENECK OPERATION (EQUIPMENT WITH HIGHEST UTILIZATION) THE CELL OUTPUT CAPACITY WAS DETERMINED

Figure 8.4 Preliminary Walnut Cell Load (Phase I)

WALNUT CELL LAYOUT (PHASE II)



1. TURN, MILL & CUT-OFF
2. TURN JOURNALS
3. DEGREASE
4. TUMBLE
5. CLEAN
6. COPPER PLATE
7. HEAT & SORT
8. PRE-ASSEMBLE
9. DRILL, REAM & ASSEMBLE PIN
10. CLEAN & DEBURR

TOTAL AREA 470 SQ.FT.

Figure 8.5 "To-Be" Walnut Cell Material Flow and Facility Layout (Phase II)

WALNUT CELL PROCESS FLOW DIAGRAM -- PHASE II

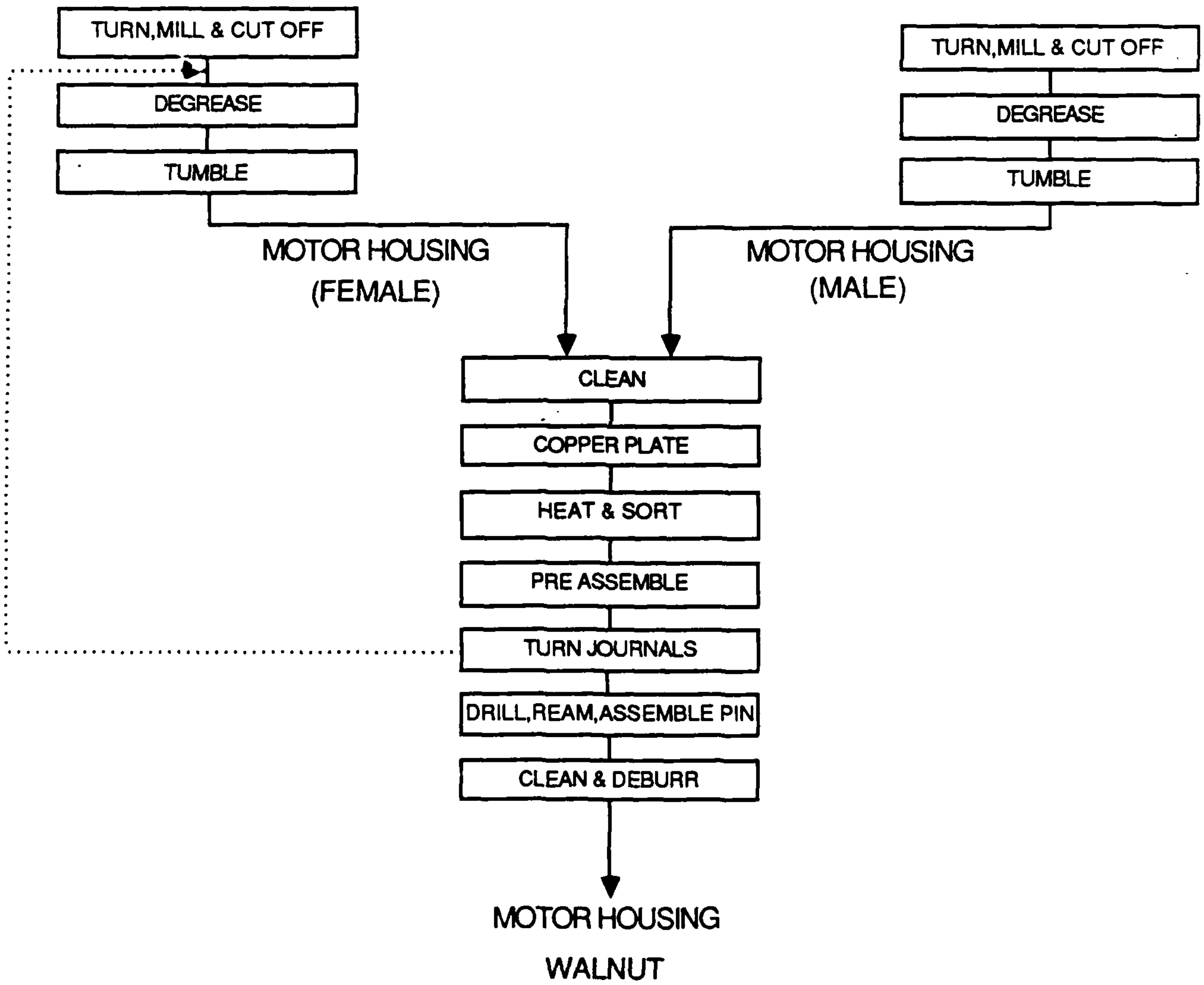


Figure 8.6 "To-Be" Walnut Cell Process Flow Diagram (Phase II)

The final (Phase II) Walnut Cell design draws upon the benefits of modern manufacturing methods and hardware. The Walnut Cell is condensed into an area of 470 square feet, and lead time is reduced to a maximum of 4 days enabling the cell to be highly responsive to production demands. Making the Walnut from solid bar stock produces a significantly more uniform and well balanced component compared to the impurities present in the extruded shell.

SECTION 9

SYSTEM/EQUIPMENT/MACHINING SPECIFICATIONS

The following are the general specifications of the equipment to be acquired or already on hand for the Walnut Cell:

- CNC lathe to be acquired:

  - 1 1/4 inch diameter bar capacity.
  - Live tooling for milling parallel to spindle axis.
  - High speed spindle with C axis control (360 degree control with .001degree increments).
  - Spindle speeds 180 - 3000 RPM continuously variable.
  - Cut-off slide.
  - Fanuc control or equivalent.
  - DNC interface with RS-232 port.

- Equipment already on hand:

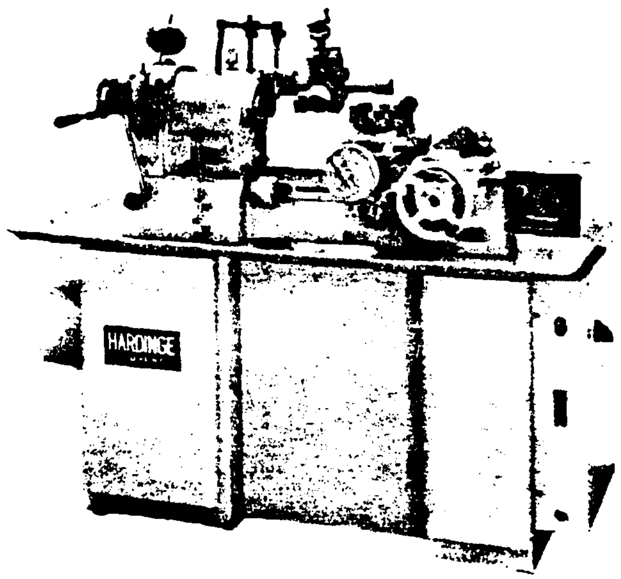
  - Vapor Degreaser; Branson, Ultrasonic Vapor Degreaser with Still

  - Tumbler
    Roto Finish
    Activation: Mechanical
    Tumbling Media: R/C 3/16 T
    Media Description: Triangle

  - Manual Chucker (Hardinge)
    See Figure 9.1

  - Jig Bore
    See Figure 9.2

HC HARDINGE CHUCKER



SPINDLE - THREADED NOSE

Speeds Infinitely Variable

Low Range 125-1100 R.P.M.
High Range 1100-3000 R.P.M.
High/Low Speed ranges changed by lever.

COLLECT: 5C - Pull back type.

COLLECT CAPACITY:	1-1/16"	Round
	3/4"	Square
	7/8"	Hexagon

All machines equipped with 6" Notrhfield chucks, installed or removed during set-up.

Maximum Fixture Diameter	9"
Maximum Single Point Threading Diameter	6" Ext., 5" Int.
Maximum Single Point Threading Length	1-3/4"
Maximum Distance From Face of Turret to Spindle	14"
Travel of Cross Slide	4-1/2"
Power Feed Range:	
Cross Slide	11/32" to 6-1/4" Per Min.
Carriage	1/4" to 10" Per Min.
Distance - Top of Turret to Spindle C/L	.375

Figure 9.1 HC Hardinge Chucker Specifications

MODEL 3 MOORE JIG BORER

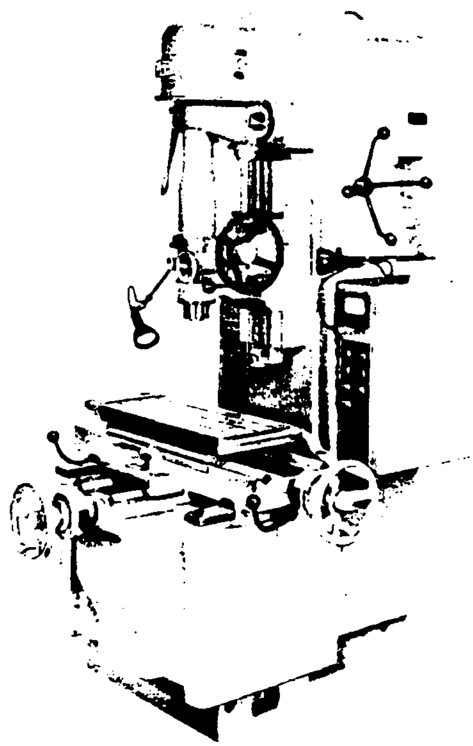


Table working surface	11" x 24"
Table travel longitudinal	18"
Table travel crosswise	11"
Table top to spindle end	3-7/8" to 20-13/16"
Vertical adj. of quill housing	11-15/16"
Spindle quill travel	5"
Spindle center to column ways	10"
Spindle center to column below	13-3/4"
Maximum Boring Capacity	
Tool Steel	5"
Soft Steel	7"
Spindle	sensitive enough for drilling holes with #80 drill (.0135")
Spindle Speeds	With two-speed motor 60-2250 RPM
Spindle Feed - 3 Feeds	.00075" - .0015" - .003" per spindle revolution
Spindle Motor	1-2 H.P.

WEIGHTS AND FLOOR SPACE

Machine with regular equipment, including motor	3860 lbs.
Shipping weight, domestic and export	4560 lbs.
Floor Space	72" x 84"

Figure 9.2 Moore Jig Borer

SECTION 10

TOOLING SPECIFICATIONS

Standard perishable tooling will be purchased for all chip removing operations while special fixtures will be required to generate certain dimensions and to maintain the functional integrity of the components. Currently, the boring operation and the journal machining operation are being performed simultaneously on a Hardinge lathe using a complex fixture. Multiple machining steps utilizing the same fixture extends the cycle time and creates an involved operation.

It is proposed to machine the journal diameter on a chore machine internal with the cycle time of the CNC lathe. This will greatly reduce the cycle time of the operation. Figure 10.1 diagrams the proposed fixture for machining the journal diameters on the female halves of the walnut. Figure 10.2 shows the concept of the drill and ream fixture to generate the gyro motor shaft bearing bores and to maintain the critical relationship with the motor housing pivot axis. Another benefit in using these fixtures is the improved quality. The present fixture causes tolerance build up due to its complexity. The proposed fixture generates the required dimensions accurately and consistently while maintaining the configurational relationships as well.

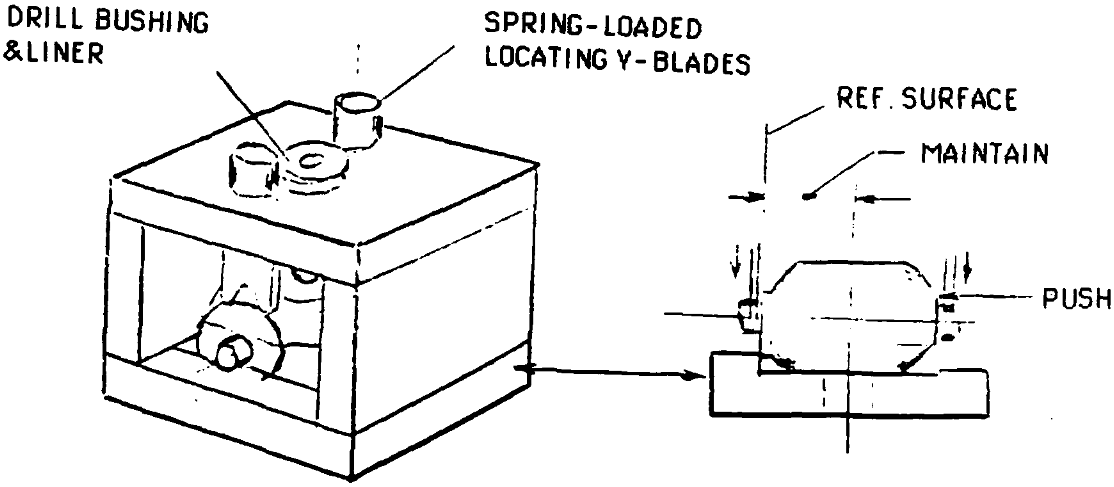


Figure 10.1 "To-Be" Walnut Journal Turning Fixture Concept

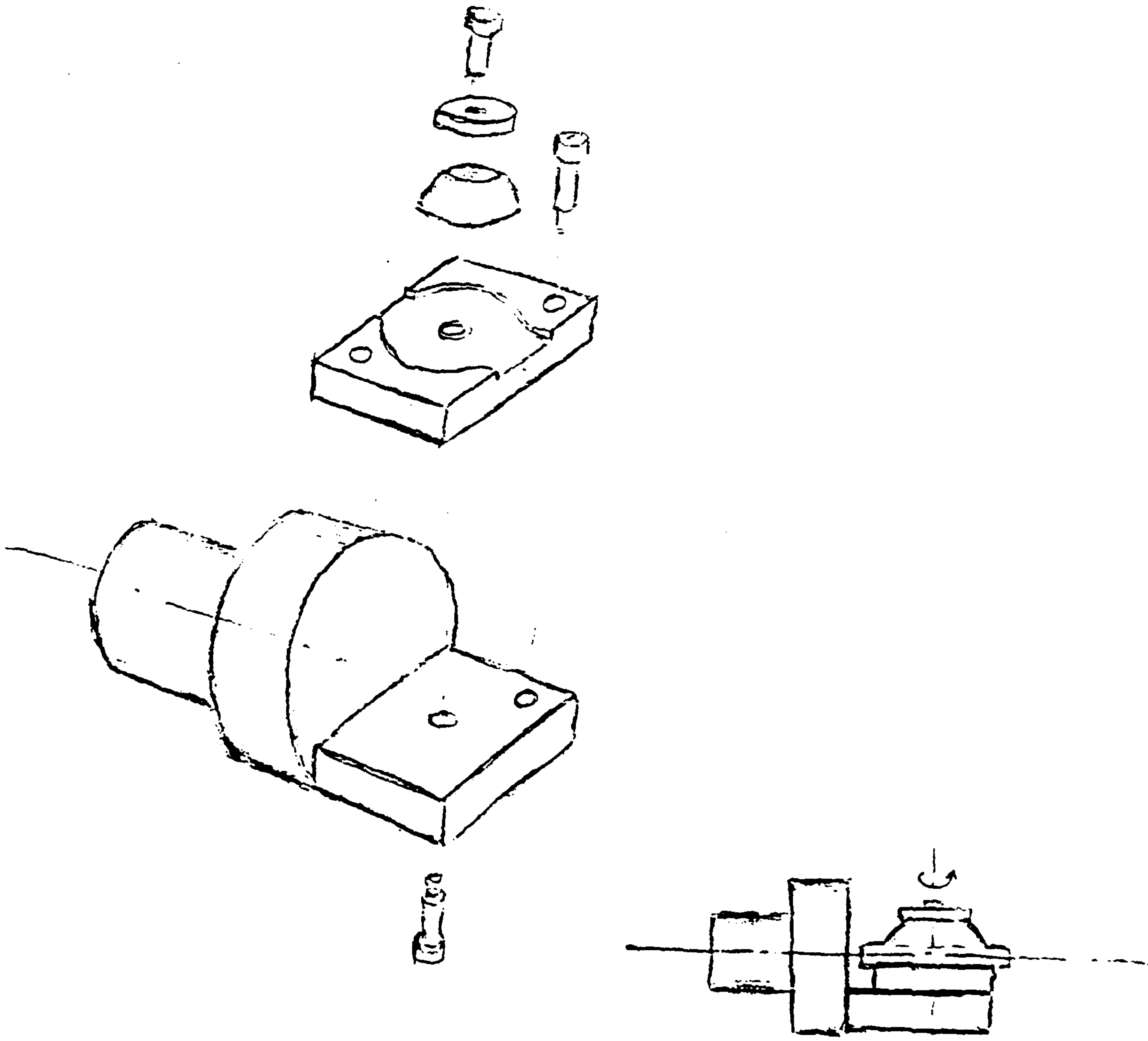


Figure 10.2 "To-Be" Walnut Drill Fixture Concept

SECTION 11

VENDOR/INDUSTRY ANALYSIS/FINDINGS

An industry search was conducted to identify the companies that would be capable equipment suppliers/integrators. In view of the many on going advances in machine tool automation and metal removal technology, we tend to think of modern automated manufacturing (CNC-Computer Numerical Control) as highly productive and efficient. The information for preparing this evaluation was obtained by:

a) Conducting an extensive literature search (local and foreign), Thomas Register, technical journals, advertisements, etc.

b) Contacting suppliers.

c) Visiting companies.

After review and assessment of the companies active in the market, several vendors were selected as appropriate, potential equipment suppliers for this cell. They were selected based on the following criteria (not listed by priority or importance):

- Capability to deliver.
- Servicing and training support.
- Machine requirements and capabilities.
- Project support in supplying pertinent data.
- Size and financial stability (as indicated by Dunn & Bradstreet reports).

Although tool cost (which reflects both the price of the equipment and its durability) is important it is not necessarily the most important criterion. Depending upon the objectives either minimum total cost of the machining operation or maximum production rate should be the ultimate criteria. The equipment utilization for the Walnut Cell is very high because everything necessary to produce the parts are in one location and a single operator runs multiple machines in the cell for optimum productivity.

The five potential suppliers selected to bid on the proposed project were:

- Ellison Machinery Comp. Mpls. MN - Representing Okuma Mfd. and Citizen Mfd.

- Hales Machine Comp. Mpls. MN - Representing Nomura

- Productivity Inc. Mpls. MN - Representing Methods Ind.

- Concept Machine - Representing Tsugami Ltd.

- Q&S Machine - Representing Ikegai Ltd.

SELECTION CRITERIA

The selection criteria for potential equipment suppliers consisted of several levels of response and evaluation (see Figure 11.1). They were also directed to be completely responsive to the specification, itemizing exceptions or alternatives proposed. Price for the equipment certainly would be a key evaluation point, but not the only one. It was asked that these vendors give time estimates, equipment and required accessories cost for evaluation. As a result, the following equipment and vendor were chosen:

- Ellison Machinery Comp. - Okuma Model LB 10 0SP

  This machine was selected because the equipment incorporates some of the most advanced engineering features and innovations available today. These features, combined with optionally available automated peripherals such as automatic gauging, robot loading, tool life management, etc. will provide a complete production system from raw material to completed product with a minimum of operator attendance. Accuracy is of great importance, and this equipment will meet or exceed all expectations requested by this investigation.

WALNUT CELL VENDOR/INDUSTRY ANALYSIS SUMMARY

CELL NAME: WALNUT CELL (VENDOR STATUS BY 6/4/87)

PART # IN CONSIDERATION:

HOUSING, MOTOR - FEMALE
HOUSING, MOTOR - MALE

GENERIC EQUIPMENT SPECIFICATIONS:

CNC LATHE, 1 1/4 DIA BAR CAPACITY WITH LIVE TOOLING
FOR MILLING PARALLEL TO (C) AXIS

EQUIPMENT & VENDOR	INFO SENT	RESPONSE	EQUIPMENT DESCRIPTION	REMARKS
OKUMA ELLISON MACH	YES	YES	MODEL LB10 OSP W/BTR INTERFACE	QUOTATION AND TIME ESTIMATES WERE RCVD
CITIZEN ELLISON MACH	YES	YES	MODEL F12	WAITING FOR FORMAL QUOTE & TIME EST.
NOMURA HALES MACH	YES	YES		WAITING FOR FORMAL QUOTE & TIME EST.
METHODS CNC PRODUCTIVITY	YES	YES	MODEL SLANT 1M	WAITING FOR FORMAL QUOTE & TIME EST.
TSUGAMI CONCEPT MACH	YES	YES	TSUGAMI-MERCURY FA45	WAITING FOR FORMAL QUOTE & TIME EST.
IKEGAI Q & S MACH	YES	YES	MODEL TCR-15 CNC MILL/TURNING CTR	MAX BAR SIZE 1 3/4 DIA, 16 STATIONS W/LIVE TOOLING TIME EST. RCVD

Figure 11.1 Walnut Cell Vendor/Industry Analysis Summary

SECTION 12

EQUIPMENT/MACHINERY ALTERNATIVES

If for some reason the preferred equipment will not be available (long lead time, capability to deliver, excessive equipment cost increase etc.) a similar machine of the same magnitude, but not necessarily of the same manufacture will be provided. This may include:

- Concept Machine Tool Sales - Tsugami/Mercury FA45.

  This machine was selected as an alternative because of its high performance and accuracy. The equipment performance is comparable to the Okuma Model LB 10 OSP in all aspects and very cost comparable.

SECTION 13

MIS REQUIREMENTS/IMPROVEMENTS

The "Walnut Cell" interfaces with the Honeywell Manufacturing System (HMS), Process Management System (PMS), and Factory Data Collection (FDC) without modification to other systems hardware or software. A complete discussion of this topic is available in Section 13 of the Project Overview.

SECTION 14

COST BENEFITS ANALYSIS/PROCEDURE

OVERVIEW

The Walnut Cell is a dedicated cell that will produce only spin motor housings (nicknamed Walnuts) for Honeywell's GNATS and GG4400 devices. The total volume of parts are made-up of six individual part numbers. Each part number has been analyzed and yearly savings have been calculated.

The reduction in actual standard hours was identified as the major cost driver for this cell. Refer to Figure 14.1 for the methodology used to identify this cost driver.

MANUFACTURING SCHEDULE

The manufacturing schedule for this cell used the marketing plan volume projections by product device. Attrition and part usage per device were accumulated to develop the ten year projections.

ACTUAL STANDARD HOUR SAVINGS

The methodology for deriving the "As-Is" and "To-Be" actual standard hours was followed as described in Section 14 of the Project Overview.

CAPITAL AND EXPENSE

The capital, recurring and non-recurring expense for the Walnut Cell are shown in Figure 14.2.

PROJECT SAVINGS AND CASH FLOWS

The savings to be realized by this cell exceed Honeywell's Military Avionics Division hurdle rate. The Cell's cash flows are shown in Figure 14.3 with the assumption that capital is available per the implementation plan.

COST BENEFIT ANALYSIS METHODOLOGY

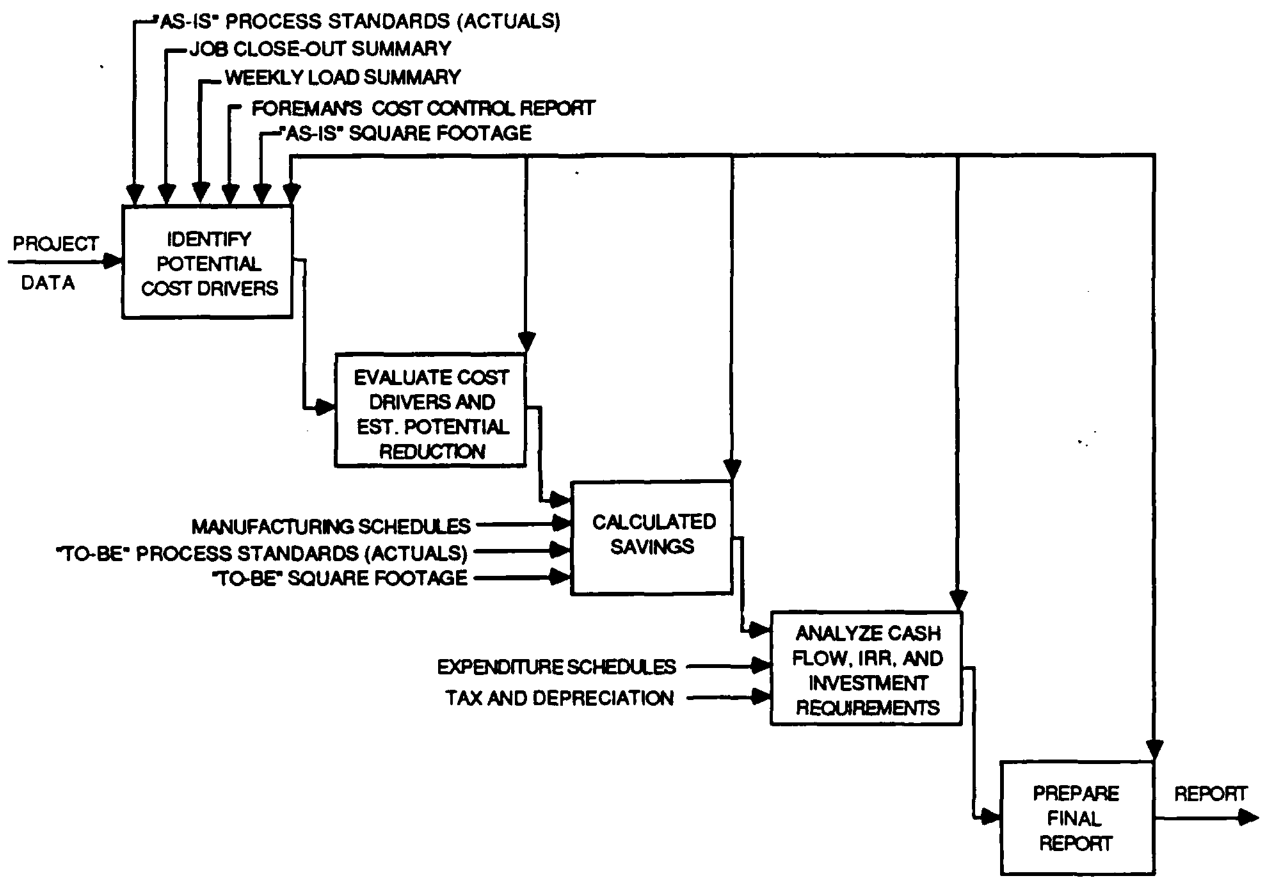


Figure 14.1 Walnut Cost Benefit Analysis Methodology

WALNUT CELL
EXPENDITURE SCHEDULE

	Cost	Capitalization Date
CAPITAL COSTS		
MACHINERY COSTS		
** CNC Lathe	$324,453	1988
** Tooling (HI)	$6,000	1988

TOTAL MACHINERY COSTS	$330,453	
FURNITURE COSTS		
** Storage Cabinet	$1,340	1988
TOTAL FURNITURE COSTS	$1,340	

TOTAL CAPITAL COSTS	$331,792	1988
EXPENSE COSTS		
NON-RECURRING EXPENSES		
Area Preparation Labor (HI)	$8,000	1988
Training (HI)	$2,000	1988
Process Development Direct Labor	$1,000	1988
Post Processor Development Direct Labor	$2,000	1988

TOTAL NON-RECURRING COSTS	$13,000	1988
TOTAL CAPITAL + NON-RECURRING	$344,792	1988
RECURRING EXPENSES		
* Annual Maintenance (Mechanical)	$2,000	
* Annual Maintenance (Computer HW)	$233	
* Annual Maintenance (Computer SW)	$233	

TOTAL RECURRING	$2,466	

* Expense starts in year 2.
** Costs contain a 15% contingency

Figure 14.2 Walnut Cell Expenditure Schedule

TECH MOD PHASE 2

PROJECT 44 -- WALNUT CELL

PROJECT CASH FLOW SUMMARY
($000)

	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	TOTAL
Capital	$331.8	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	$331.8
Non-Recurring Expenses	$13.0	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	$13.0
Recurring Expenses	$0.0	$0.0	$2.5	$2.5	$2.5	$2.5	$2.5	$2.5	$2.5	$2.5	$2.5	$22.2
Total Savings	$56.9	$320.7	$345.3	$330.8	$343.8	$360.3	$377.9	$396.4	$415.1	$434.2	$339.9	$3,721.2
Depreciation	$33.1	$59.6	$47.7	$38.2	$30.6	$24.5	$19.6	$22.4	$22.4	$22.4	$11.4	$331.8

Figure 14.3 Walnut Cell Cash Flows

SECTION 15

IMPLEMENTATION PLAN

The proposed implementation plan is based on the assumption that capital funds for the project will be incorporated in the 1988 capital plan and that these funds will be available during the second quarter of 1988. It also assumes that adequate space will be made available at this time.

The following is a description of the activities shown in Figure 15.1 on the Walnut Cell implementation plan schedule:

BUILD AND TEST PROTOTYPE

The implementation of the Walnut Cell depends upon the successful completion of the prototype parts that will be produced on the CNC lathe. The produced parts should go through an engineering evaluation and process approval procedures.

CAPITAL EQUIPMENT

Prepare purchase order and issue to the vendor after funds are available. The Project Manager should check the status of the order on a regular basis, to make any adjustments to related activities if and when necessary.

TOOLS AND FIXTURES

The fixtures will be designed by the Honeywell Tool Design department. After the fixtures have been approved by engineering, they will be built and tried out on the new CNC lathe before final phase-in occurs.

BUILDING PREPARATION

This is mainly a Facility Services activity. The project manager should maintain close contact with Facility Services to assure the timely accomplishment of the work involved. Before moving any kind of equipment, the power, air and any other support installation should be prepared so that equipment moves will not interrupt production activities.

TRAINING

This is a major activity in the schedule. Serious consideration should be given to training the operators on the new CNC equipment that is to be received. The success of the project relies heavily on the quality of the training the operators are provided.

WALNUT CELL
IMPLEMENTATION PLAN

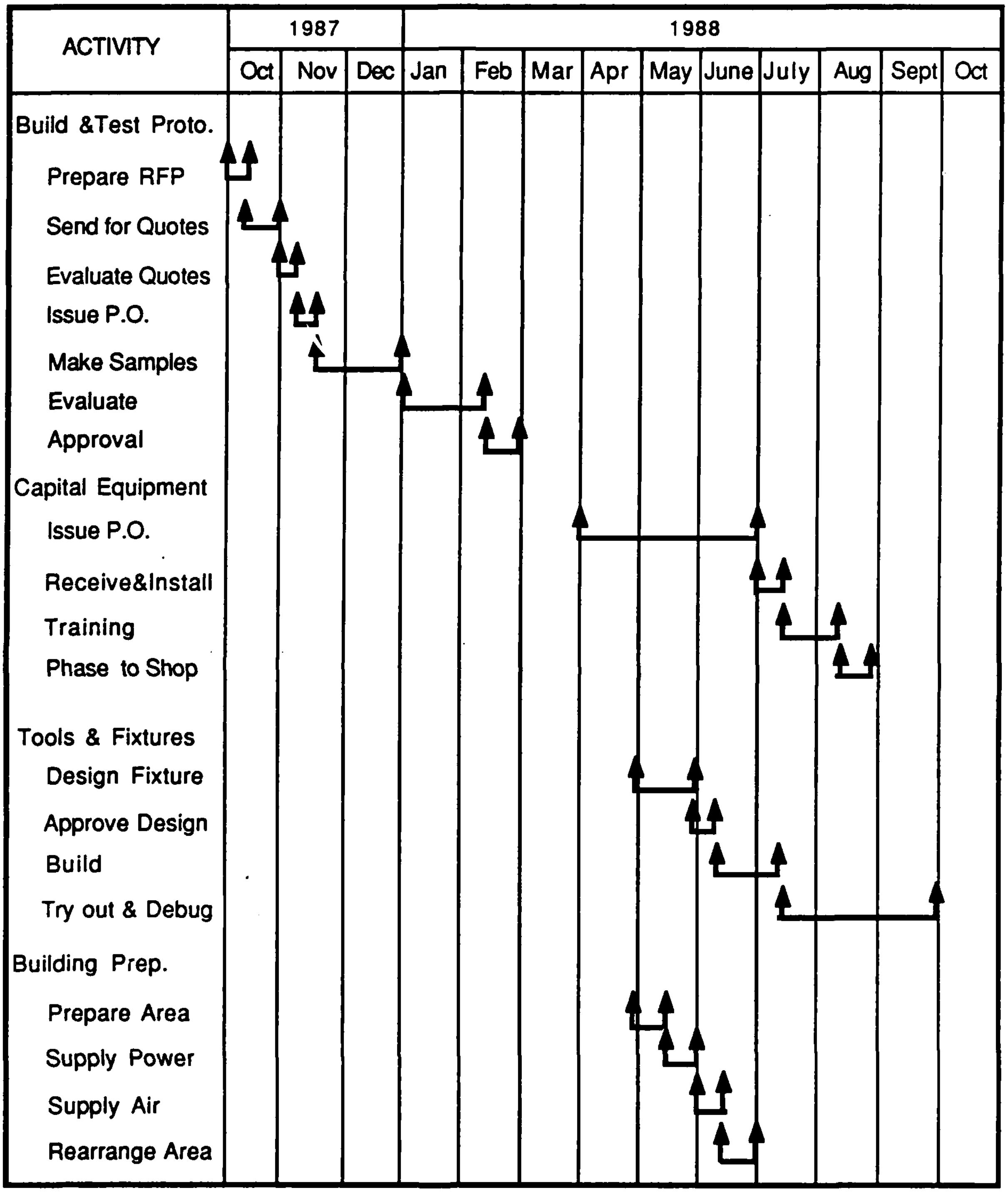


Figure 15.1 Walnut Cell Implementation Plan

SECTION 16

PROBLEMS ENCOUNTERED AND HOW RESOLVED

No major problems were encountered during this project.

SECTION 17

AREAS FOR FUTURE CONCERNS/DEVELOPMENT

FUTURE CONCERNS

The capacity of the Walnut Cell is based on a forecast projected out for ten years. If this forecast changes, the capacity requirements and cell design parameters will also change.

It is not known at this time if such a change will occur. If it does, it will affect the project in two ways:

1. Increase in forecast:
   In this case, the newly acquired CNC equipment may be saturated for two shift operations and as a result, either overtime or third shift operation will be required. This is a situation that can be dealt with, because it indicates increase in business and more savings.

2. Decrease in forecast:
   This will cause under-utilization of the CNC equipment. In turn, anticipated savings will not be realized and the rate of return will go down, indicating a less profitable investment.

FUTURE DEVELOPMENT

The copper plating requirement of the Walnut components necessitate the machined parts to leave the cell area. This situation brings two thoughts into consideration:

- Integrate the copper plating operation within the cell area by acquiring suitable equipment.
- Find another method of applying copper to the required areas of the Walnut Cell.

If the above integrations could be possible, it would have a positive effect on material handling, material control, manufacturing cost, lead time, and quality.

PROJECT 44

SHEETMETAL CELL

SECTION 1

INTRODUCTION

Honeywell's Fabrication Facility (Fab Fac) is a support manufacturing plant which supplies hardparts to various groups within the Military Avionics Division. Sheetmetal Fabrication is one area of support and will be the main focal point of this report. Eighty to eighty-five percent of all Fab's sheetmetal work load is received from Test Systems and Logistics Operations (TSLO). This group is a supplier of electronic diagnostic test stations to the military for avionics applications. The structural skeleton of these large test stations consists primarily of aluminum sheetmetal, .125 of an inch in thickness or less. Sheetmetal sizes typically range from small washers of .250" in diameter to formed bracketry punched from 3' x 4' sheets. Design requirements on features of size, typically are controlled to ±.005" while positional tolerances range between ±.003" to ±.020". Driven by TSLO's marketing schedules, the majority of the sheetmetal parts manufactured at Fab Fac are prototype build and small quantity production (one to fifty parts per run). Given these quantities along with a high population of different sheetmetal parts being produced, set-up and material flow is the main areas of concern. Product contract delivery dates are being bid on shorter time lines, consequently sheetmetal lead times have become unacceptable. This provides the opportunity for the formation of a cellular manufacturing structure called the "Sheetmetal Fabrication Cell" which will improve material flow, set-up, productivity and leadtimes.

SECTION 2

PROJECT PURPOSE/OVERVIEW

Currently, the manufacture of sheetmetal in Fab Fac is inhibited from being cost effective by poor material flow, long set-up times and from worn/outdated equipment. The main objectives of the Sheetmetal Cell are to improve productivity and throughput time for TSLO and other sheetmetal users. This objective will be accomplished by:

- Integrating multiple operations into one.
- Reducing set-up time by renumbering, organizing and replacing tooling.
- Eliminating excessive material handling.
- Improving burring capabilities.
- Minimizing Work-In-Process (WIP) inventory.
- Purchasing new equipment.
- Developing a celluar manufacturing structure to optimize material flow.

SECTION 3

TECHNICAL APPROACH

The current method of manufacturing sheetmetal was analyzed by two manufacturing engineers. Problems and concerns were gathered by informal meetings with factory operators, production control coordinators, programmers and Test Systems and Logistics Operations (TSLO) customers. After analyzing the problems and concerns, and studying the current processes, opportunities for improvements were identified. The approach taken to derive the sheetmetal cell proceeded as follows:

1. Manufacturing volume growth was obtained from the TSLO marketing department. These projections gave the "To-Be" measurement for capital justification and cell loading.

2. A thorough equipment and technology search was conducted to determine the best selection of equipment for this cell. Cellular arrangement of this equipment allowed improvements in material flow, part quality and set-up procedures.

3. An assessment of all existing furniture was made for determining use, replacement or removal. The assessment was made on the basis of freeing up floor space, tooling storage, organization, and material flow. Furniture was selected to best fulfill this criteria.

4. A manufacturing "To-Be" process was established on the basis of average time per job. From an average production time per job along with marketing volumes, cell simulation, manpower requirements and cell capacity were derived.

5. The feasibility of the project was confirmed by comparing the differential between the "As-Is" and "To-Be" manufacturing cost. A formal financial analysis of project savings, cash flow expenses and IRR gave this confirmation.

6. After completion of the final design, an implementation schedule was prepared for the procurement and arrangement of machines and furniture.

SECTION 4

"AS-IS" PROCESS

INTRODUCTION

The Honeywell Fabrication Facility (Fab Fac) is a support manufacturing plant structured in the form of a traditional job shop. The IDEF chart shown in Figure 4.1 shows the facilities overall "As-Is" workflow process.

Eighty to eighty-five percent of all Fab's booked sheetmetal workload is received from Test Systems and Logistics Operations (TSLO). This group is a supplier of electronic test stations to the military for aviation diagnostics. The structure of these large test stations consist mainly of aluminum sheetmetal, .125 of an inch of thickness and under. Driven by TSLO's marketing schedules, the majority of the sheetmetal parts manufactured at Fab Fac are prototype build and small quantity production. Production quantities range from one to fifty pieces per run. With low quantities, the production load is made up of a high population of different sheetmetal parts which create high set-up costs.

The current "As-Is" manufacturing process is not designed to be efficient in running low volume sheetmetal competitively. The areas of inefficient operations are described below.

SHEETMETAL PROCESS GENERATION

The product design is drawn at TSLO manually or on CAD CAM terminals. The design is conventional with just enough information given, so the drawing will stand alone. Orders are generated and prints are sent through document control to Fab's pre-planning group. The print is then given to a Production Engineer for process development. The process is developed by the following method:

1. The print is reviewed and tooling is ordered if needed.

2. A print is given to a union tool designer who:

    - Manually draws a flat representation of the sheetmetal part.
    - Chooses punches and calls out punchpress turret assignments.
    - Manually calculates all X, Y coordinate punch locations, adds in bend allowances and writes these dimensions on the flat pattern.
    - Enters blank size to be used and pieces per blank to be programmed.
    - Logs print into Document Control.
    - Returns the part print along with the flat pattern print to the production engineer.

3. A program is manually written from the X,Y coordinated flat pattern.

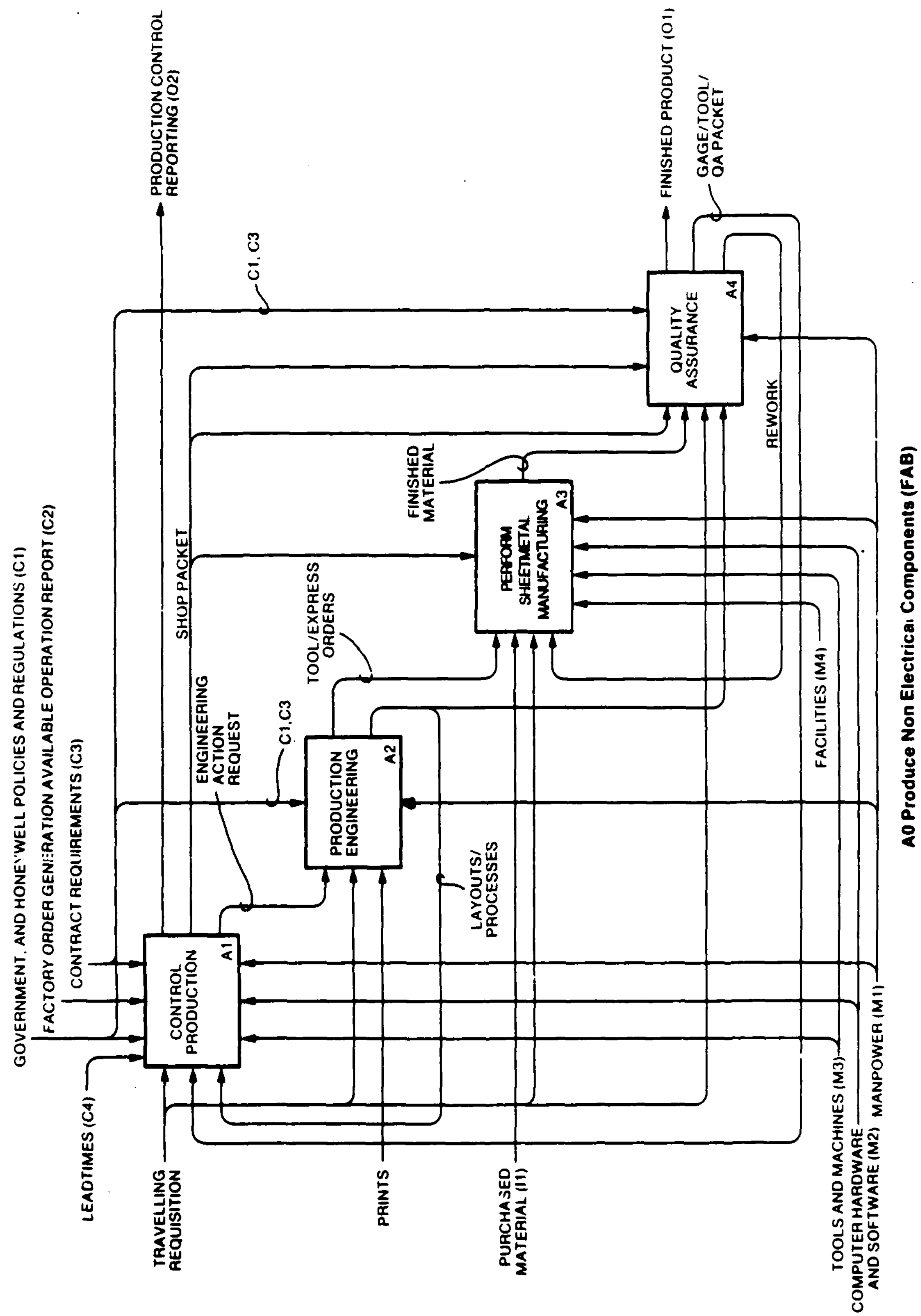


Figure 4.1 Sheetmetal "As-Is" Workflow Diagram

4. The program is given to the secretary for inputting into the computer.

5. The program is plotted to detect and remove gross programming errors.

6. Operation set-up and run detail sheets are developed and standard run hours are calculated.

7. The sheetmetal layout for forming, metal finish and installation of fasteners is completed.

8. The layout is routed through the engineering sign off loop and submitted to planning for production.

9. A paper NC program tape is punched and delivered to the floor for production.

With manual programming, there is a high frequency of programming errors. These errors are detected on the punch press after the first piece inspection. With the machine on down time, the program is corrected by a programmer or an engineer. This inefficient processing method is a result of using old programming technology. Figure 4.2 shows the sheetmetal process generation work flow through production. The high lead times of 3 - 4 weeks are generated in this linear type of processing. This process is unacceptable for meeting product delivery dates.

INSPECTION PROCESS

All hole to hole locational tolerances and geometric shapes are inspected off the first production piece on the Cordax Measuring Machine. The piece part is inspected to the flat pattern drawing and if correct, this part becomes a master overlay for use on future production runs. When a Engineering Change Order (ECO) occurs, this master overlay becomes invalid and the inspection procedure must reoccur. Currently, there are over 1500 active sheetmetal parts in flat pattern storage. This storage is in cabinets in the Sheetmetal Production Department and is utilizing needed production floor space. This system of inspection relies on accurate flat pattern drawings and forming with the correct bend radii. Final inspection is visual with the exception of rough overall measurements.

MATERIAL FLOW

Material is sheared to blank sizes specified by the layout in the tool crib and delivered to storage racks in the Sheetmetal Cell. Usually there is material buffered in this area for 2 to 3 weeks of production. Each job is set-up and run through the punch press and stored on shelving awaiting drilling or forming. The part is scheduled through the press brake and shelved until moved by the stores personnel. The piece parts moving to the drill press must be hand carried 70 feet to the machine and 70 feet back to parts storage. Strip material processed through the hydraulic presses cannot be fed smoothly through each machine because of a congested arrangement. Figure 4.3 diagrams the described "As-Is" material flow on the existing floor layout.

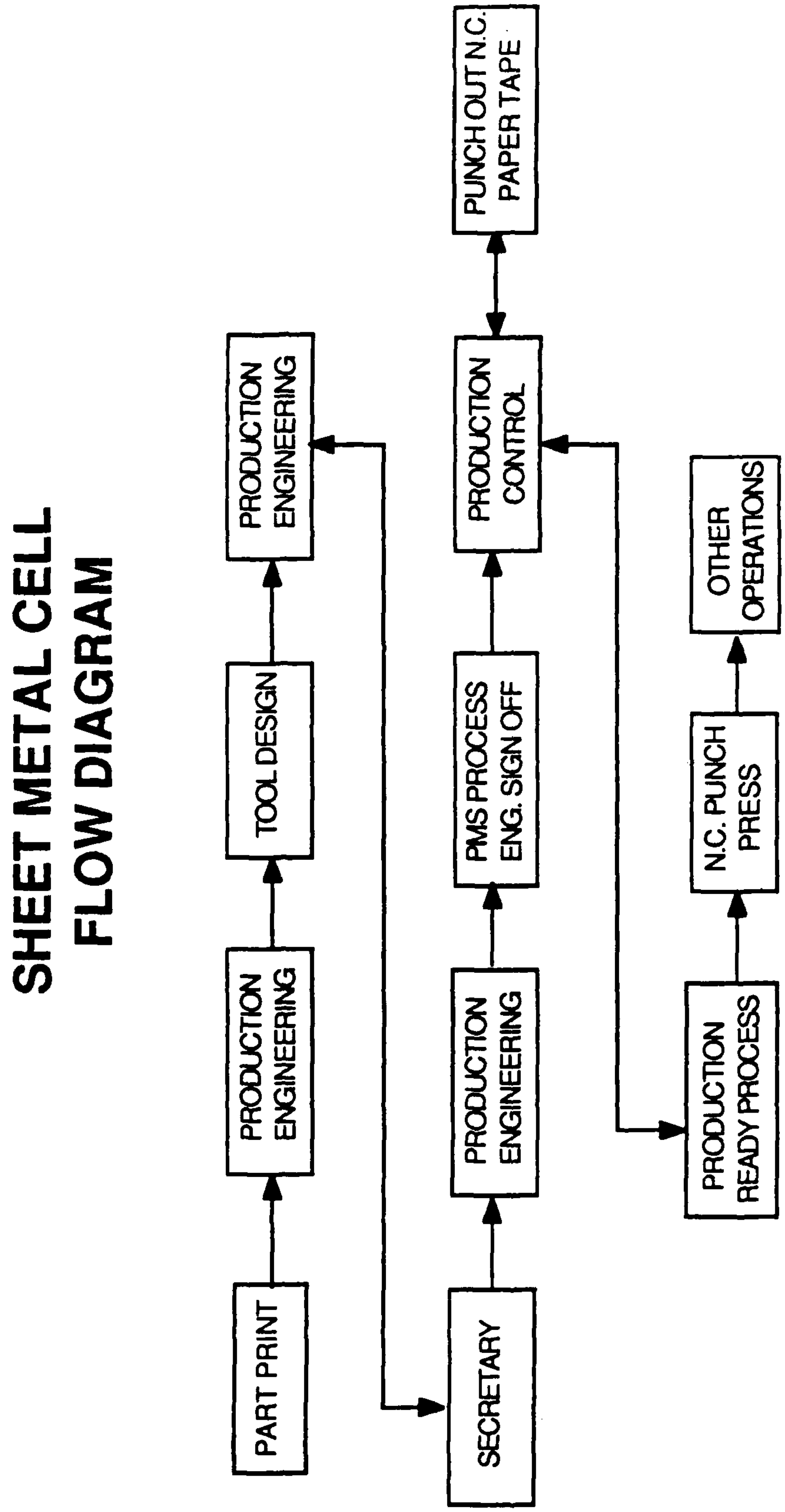


Figure 4.2 "As-Is" Sheetmetal Process Generation

SHEETMETAL CELL AS IS LAYOUT AND WORK FLOW DIAGRAM

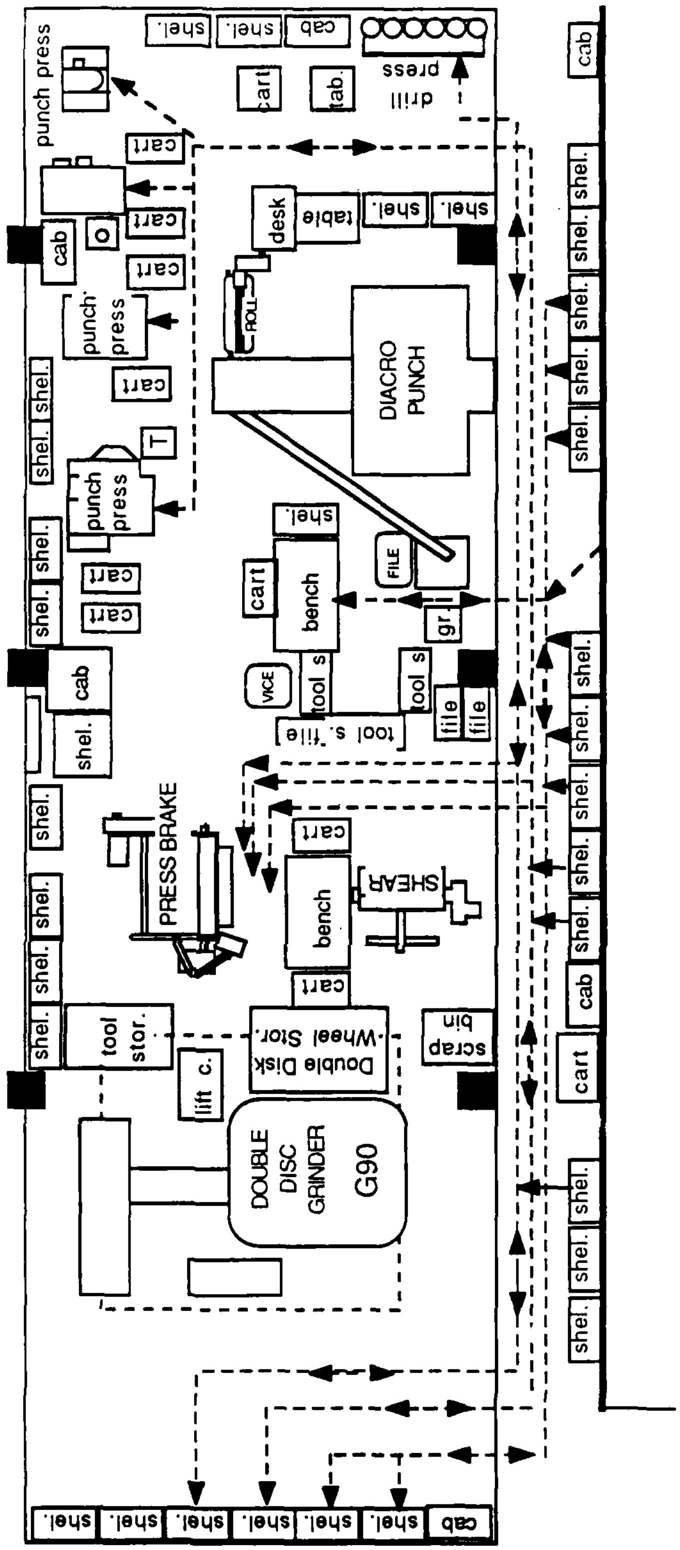


Figure 4.3 "As-Is" Sheetmetal Cell Layout and Work Flow Diagram

PROCESS REQUIREMENTS

In sheetmetal production, certain capabilities are required to satisfy customer needs and part quality. Scalloping or nibbling marks from punching the perimeter of a part must be kept to a minimum to reduce high spots. These spots which cause part interference in assembly must be removed by deburring. The punch press turret wear, which is causing punch and die shear, creates larger scallop marks. This results from the punch traveling to the far side of the die's clearance in the punching process.. Only complete rebuilding or replacing of the punch press can correct this problem.

Removal of burrs is currently labor intensive. Tabs that hold the finished parts into raw material blanks are removed by air actuated hand held scissors and filed smooth to the parts edge with a reciprocating file. All sharp exterior edges are removed by a scotch brite wheel mounted in a pedestal grinder. Sharp edges on interior windows and cut outs are removed by hand deburring tools. For cosmetic reasons, front panels on test stations need to be straight lined sanded. This puts a mat finish on the part and removes burr and scratches. This operation is currently subcontracted because Fab does not have this process capability. Straight line sanding would minimize some of the labor intensive deburring if this operation was within the punch press work envelope.

EQUIPMENT

The Diacro VT36 is a fifteen year old NC punch press and is currently loosing the ability to hold positional tolerances. To monitor the machine's wear, quarterly testing of positional tolerances are made to certify the machine's accuracy. No parts on this machine may be produced with hole-to-hole tolerances of less than $\pm$ .006". The maintenance hours needed to keep this machine in production are on the rise which leads to higher down times. To add to these problems, alignment of punches and dies between the top and bottom turret is very poor. This is evident from rolled burrs showing up on one side of a cut-out. From this mismatch, punch and die shear is common resulting in an average of fifteen tool regrind hours per week.

The 50 ton Chicago Press Brake was procured in 1959. This machine is in very good working condition and is equipped with a Hurco NC control. This control allows multiple bends of different lengths to be carried out in one operation with no additional set-up. Given the low run quantities, this feature in not utilized to its full potential.

Other equipment include: four Denison Presses in moderate to good working condition; a Diacro 36 inch roller - rollers need to be ground; a 36 inch Niagara Shear in good working condition: pedestal grinder; reciprocating file, and a 6 spindle drill press.

TOOLING

One quarter of the Punch Press' 112 style tooling is at one half of its usable life. Storage of this tooling is in small inefficient drawers, walled around the press. There are four different numbering systems interrelated which has caused the need for cross reference charts. These charts are controlled by the production operator and give information of drawer location and tooling size. To find tools, continuous use of these charts are necessary. As a result, the tooling organization and numbering system used is causing unwanted higher set-up times.

The press brake tooling is stored in horizontal and vertical holding racks with lengths up to six feet. Other small punches and dies are stored in various drawers with no common location. Punches and dies vary in height which inhibits flexible set-ups and full utilization of the tooling. Organization and commonality in tooling heights is the key to quicker set-ups. These characteristics are currently lacking and need to be improved.

DISADVANTAGES OF CURRENT METHODS - A SUMMARY

- The sheetmetal process generation procedure creates unacceptably long lead times. This is caused by manual programming and processing in a linear work flow pattern. Figure 4.2 shows this pattern.

- The current inspection process causes machine down time and utilizes needed production floor space. All active sheetmetal flat patterns are stored on the factory floor. Inspection occurs on the first production piece off the punch press. This causes unwanted machine down times.

- The NC Punch Press is production inefficient in two ways: One, its ability to hold positional tolerances and two, the low linear positioning and punching speed.

- The punch press set-up time per job is inefficient. This is a result of unorganized tool storage, complicated tool numbering systems and inefficient storage cabinets.

- The material flow from raw material in to finish goods out prevents a smooth product flow and reduces productivity. This is directly related to the current unorganized, congested floor layout.

- Large scallop marks on sheetmetal parts create the need for labor intensive hand deburring. This problem is directly caused by punch press turret wear.

CURRENT SHEETMETAL PRODUCTION PROCESS - An Amendment

The Metrology Lab monitors turret and lead screw wear of the punch press quarterly. Positional tolerance testing of the Diacro VT 36 punch press failed in the third quarter of 1987 during the writing of the final report. Extensive maintenance efforts were made to repair the press to meet production standards but all efforts failed. With the original company out of business, replacement parts could not be procured or fabricated cost effectively. It was determined the machine would be surplused and sold at scrap value. Currently all sheetmetal production parts with hole-to-hole locational tolerances of less than $\pm$ .010" is subcontracted complete. This constitutes approximately 95% of all Fab's sheetmetal production load. Two certified Honeywell vendors were selected for sheetmetal subcontract work. VID Metal Products and Mid Continent Engineering was chosen under the criteria of capability to deliver, past association with Honeywell, part quality and willingness to support.

SECTION 5

"TO-BE" PROCESS

INTRODUCTION

The manufacture of sheetmetal in the Fabrication Facility (Fab Fac) was inhibited from being cost effective by poor material flow, high set-up times, unorganized tooling and worn outdated equipment. The objective of forming the Sheetmetal Cell was to improve productivity and throughput time for Test Systems and Logistics Operations (TSLO) and other sheetmetal customers. TSLO supplies Fab with eighty to eighty-five percent of the sheetmetal production load. The nature of TSLO's yearly booked business is small quantity build and shipment of large diagnostic test stations. The structure of these test stations is made up of a high population of different aluminum sheetmetal parts which Fab Fac produces. As a result, sheetmetal production is mainly in low quantities of under fifty parts per run. By restructuring the current sheetmetal manufacturing department into a flexible manufacturing cell, the capability to run low to high volume parts cost effectively, will be achieved.

SHEETMETAL PROCESS GENERATION

The overall work flow of the manufacturing process is diagrammed in Figure 5.1. This IDEF diagram shows a comprehensive flow of each control system and its tie to the overall manufacturing structure. Focussing attention on the "Sheetmetal Fabrication Cell", the following will describe the "To-Be" sheetmetal process generation.

The product design is initiated at TSLO primarily on CAD terminals. The design is conventional with just enough information given, so the drawing will stand alone. Orders are generated and prints are sent through document control to Fab's pre-planning group. A Production Engineer receives a print from pre-planning and develops a process using the following method.

1. The print is reviewed and tooling is ordered where needed.

2. The print is given to a union Tool Designer who works jointly with a union Programmer to develop a CNC Punch Press program. Digitized CAD geometry off the print is linked to the Distributed Numerical Control (DNC) programming system. Sheetmetal programming software enables the programmer from a library of available tools stored on the hard drive, to align punches to conform to the received sheetmetal data. A program that will not violate print dimensions will be generated internally with all bend allowances by known centerlines of the tooling. The program is stored on the DNC file server for production.

3. Processing in parallel to the programmer, the Production Engineer finishes the overall formal part process.

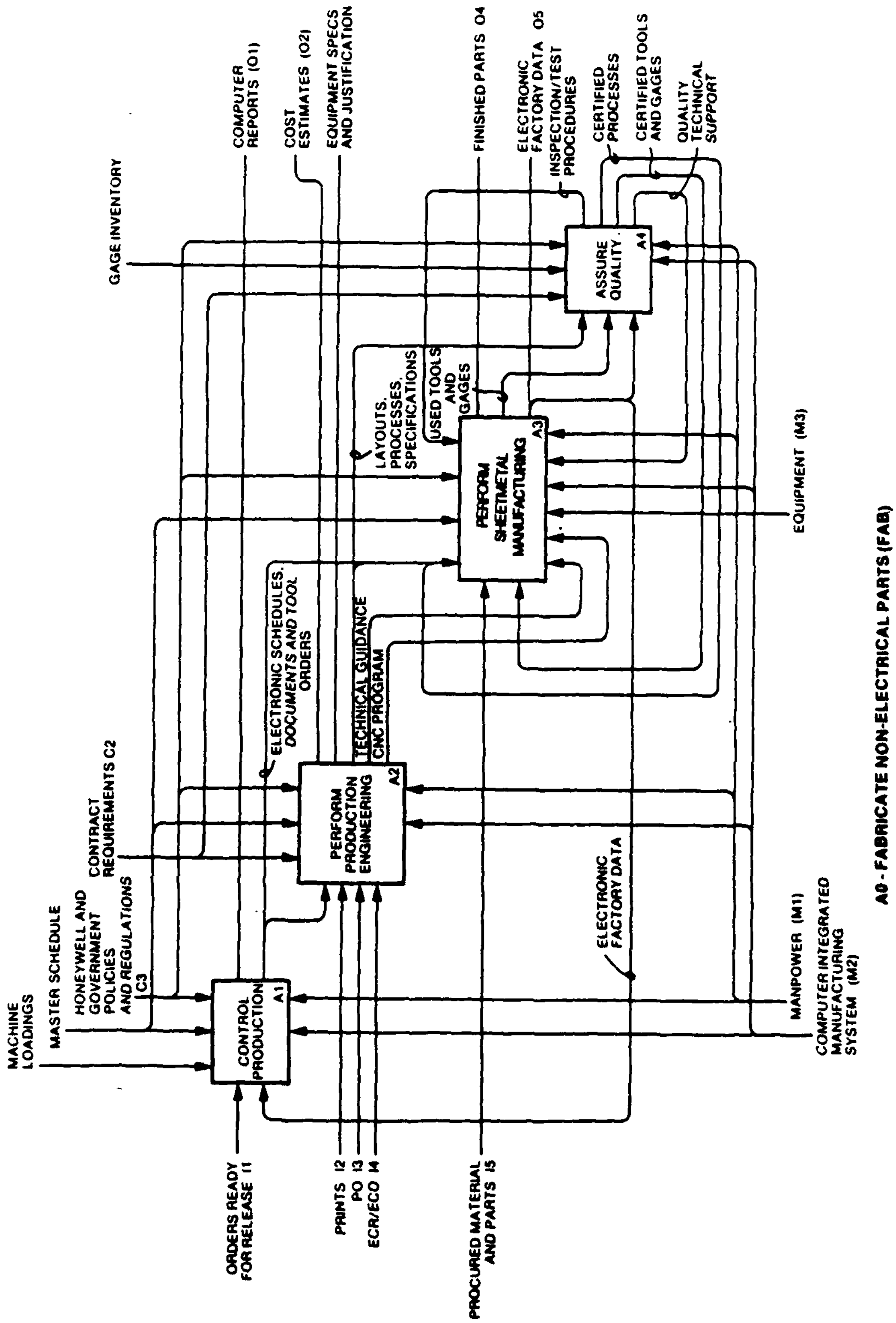


Figure 5.1 "To-Be" Sheetmetal Workflow Diagram

4. The finished process is routed through the Honeywell Manufacturing System (HMS) for engineering sign off to establish process integrity.

5. An order is scheduled through a CNC Turret Punch Press where the operator receives the program containing set-up and run instructions from the DNC file server. This information is prompted on the CRT of the machines Fanuc Control.

Figure 5.2 diagrams this "To-Be" process generation procedure. As a result of this "To-Be" process, lead time reduction is up to 3 weeks and process time is divided in half. This allows Fab to be process flexible from operating in a prototype build environment to a high production setting.

INSPECTION PROCESS

On all first run production jobs, hole to hole positional tolerances and geometric shapes are inspected on a Cordax Measuring Machine. When the Flat Pattern passes the inspection audit, the Punch Press program becomes certified. This entitles all following production runs to be carried out without inspection. A certified program loses its certified status when a program is altered or when a print revision change occurs.

This removal allows approximately 74 square feet of floor space to go back into production. As a result of this "To-Be" inspection process, punch press in-process idle time is reduced 20 percent. With the removal of the flat pattern storage cabinet, operator responsibility is more directed toward production and less towards shelf organization.

PUNCH PRESS AND SUPPORT EQUIPMENT

The Wiedemann Centrum 2000/Q CNC Punch Press will talk directly with the DNC programming system through the DNC file server. This communication link will take place through the machines Fanuc 6MB Control and will allow the removal of all paper program tapes and set-up detail sheets from the floor.

When comparing machine specifications from the old DIACRO VT36 to the new, Figure 5.3, it was found that the new machine could out perform the old 2.5 to 1, clearly showing the advancements in technology. The performance rating of the Wiedmann shows an impressive 2000 inches per minute positioning speed, a 2 second tool change time, 30 rpm Turret Rotation and punching speed up to 350 hits per minute. This machines performance will reduce production time 45%. The small parts auto off-load chute and conveyor will transport sheetmetal parts, up to 10 x 10 inches, to the operators work area. This feature eliminates the labor of removing and filing of tabs that hold finished parts into the raw material blank. To reduce the labor intensive burring, a "Timesaver" straight line sander was added. This wet sander will remove burrs from the punch break out side of the sheetmetal and give cosmetic mat finishes to front panels.

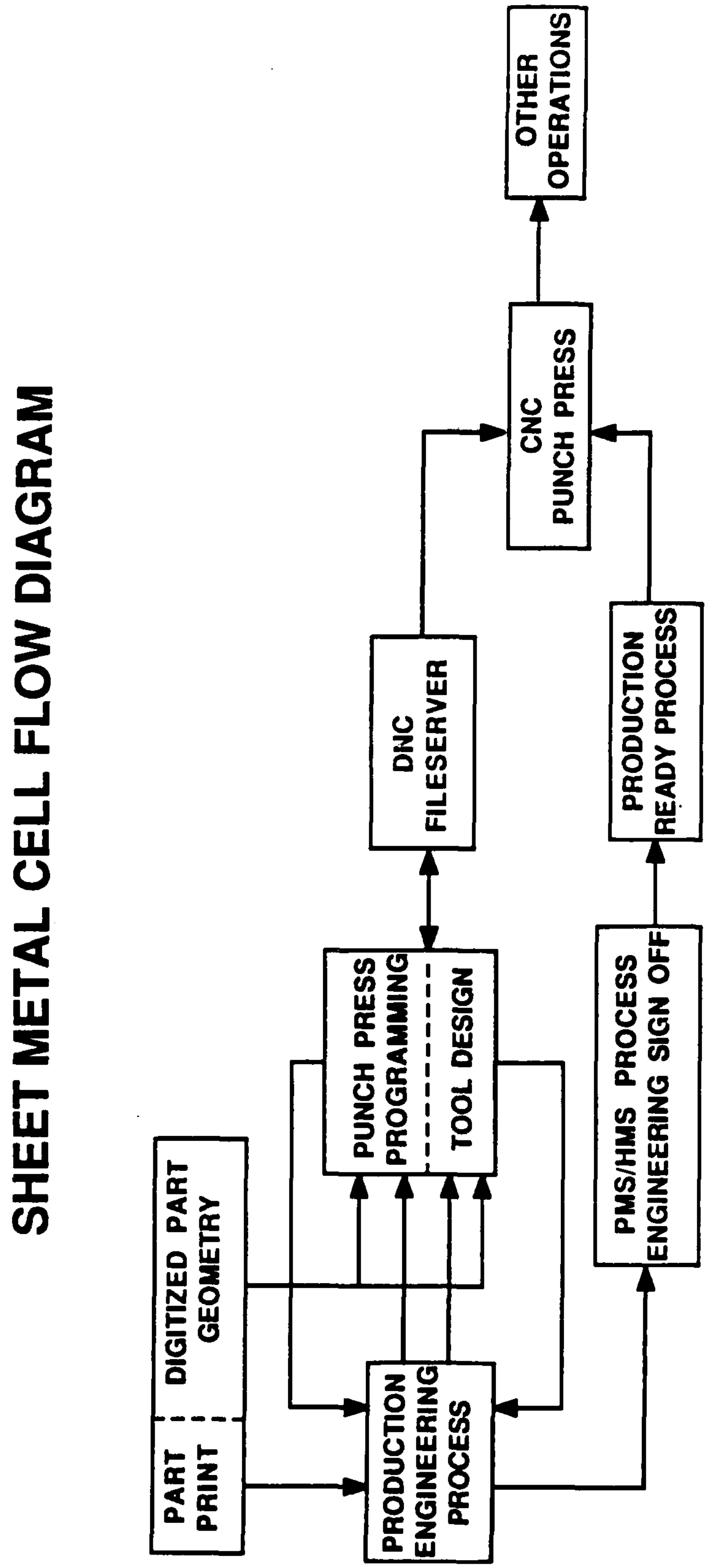


Figure 5.2 "To-Be" Sheetmetal Process Generation

SHEET METAL CELL

MACHINE SPECIFICATION COMPARISON

SPECIFICATION	WIEDEMANN CENTRUM 2000/Q	DIACRO UT-36
AVE. TOOL CHG TIME TOOL ROTATION TIME	2 SECONDS 10 DEG / STROKE	4 SECONDS N/A
LINEAR POSITIONING SPEED	2000 IPM	735 IPM
TURRET ROTATION SPEED	30 RPM	9 RPM
HIT RATE / AXIS MOVE	HITS/MIN	HITS/MIN
.2 INCH	350	130
1 INCH	200	
2 INCHES	170	
3 INCHES	155	
6 INCHES	130	
10 INCHES	100	
PUNCHING ACCURACY	+/- .005	+/- .005 WHEN NEW
MIN. WORKHOLDER DIST. FROM PUNCH CENTER	3.540	3.100
PUNCHING CAPACITY	3.500 DIA.	3.125 DIA
TOOL CAPACITY	22 STA.(2) INDEXABLE	20 STATION
CONTROL	FANUC 6MB (CNC)	G.E. 550 (NC)
RATED TONNAGE	22 TONS	15 TONS
MAX. MATERIAL THICKNESS	.250	.250
TOOLING STYLE	112 OR 114 STYLE	112
THROAT DEPTH	41.300	36.000
(X,Y) MAX. WORKPIECE DIMS.	48" X 40"	36" X 36"
(X,Y) MAX. TABLE TRAVEL	50" X 40.5"	36.5" X 36.5"
(X,Y) SPACE REQUIREMENTS	10'3" X 11'6"	9'6" X 12'9" (WITHOUT CONTROL)
COOLANT	N/A	N/A
AIR SUPPLY NEEDED	3.5 CFM @ 70psi	30 CFM @ 80psi

Figure 5.3 Punch Press Comparison of Machine Specifications

TOOLING

The tooling for the present punch press is compatible to the new CNC Punch Press. Three hundred jobs were randomly sampled out of an active job population size of 2000 to determine punch press tool usage. From these findings, punch holders for the sixty most frequently used punches will be procured. These tools are to be set-up permanently for ready use.

The machines feature of tool rotation within the Turret will allow an average reduction of 1.5 tools per set-up. Positive alignment of the line bored turret will eliminate the operators need to center tooling clearances. A new tooling numbering system will be introduced. Each tool number will indicate tool size and geometric shape. Tool storage cabinets will be procured and all punches and dies will be organized by this numbering system. This system will eliminate the four different numbering systems and the operator cross reference charts. By tooling up for quick tool change over, organizing tooling by a new numbering system in efficient storage cabinets, and using the tool rotation feature, set-up will be reduced 50%.

FACILITY LAYOUT/MATERIAL FLOW

The formation of the "Sheetmetal Cell" localizes sheetmetal production in a rectangular area. Sheetmetal parts are to be produced following two separate material flow paths. Figure 5.4 shows these material flow paths within the "To-Be" facility layout.

Focusing attention on flow path one in Figure 5.4, material is delivered from central stock for one to two days production and is buffered on two-way accessible shelving. Material sheets for each short run job is loaded on a foot actuated, hydraulic lift cart, prior to the start of each run. For high volume runs, the lift cart is loaded with a pallet of material and wheeled back into the production area. As material is used, the cart table top is actuated up to the punch press table to reduce operator fatigue.

Raw material is punched in a 22 ton CNC punch press. Small parts up to 10 inches square are punched complete and delivered to a hard maple work surface by a 12 inch wide belt conveyor. Larger parts will be carried to the work surface where parts are clipped free from the sheet by a counter balanced hand held air scissor. The scrap portion of the sheet is slid into the scrap material out bin. Tabs are removed by a reciprocating file and sharp exterior edges are removed by a scotch brite wheel mounted in a pedestal grinder. To deburr the punch break outside, parts are fed through a 24 inch vertical straight line wet sander that does not disburse metal dust into the air. A second function of the sander is to produce a mat finish on the front panels. The finish sanded parts drop into a cart where the parts are delivered either to the drill press material rack or to the staging area labeled "Parts Awaiting Forming".

Finished parts are carried to the finish goods out rack. When the drill press work is completed, parts are either sent to awaiting forming or carried to the outgoing racks. Material is formed to it's finished shape by a Chicago Press Brake and put on the finished goods out shelving to be shipped to the metal finish department.

The second flow path shown in Figure 5.4 is through the four air and hydraulic press brakes. Incoming material is blanked and formed to it's finished size by being routed through any combination of machines.

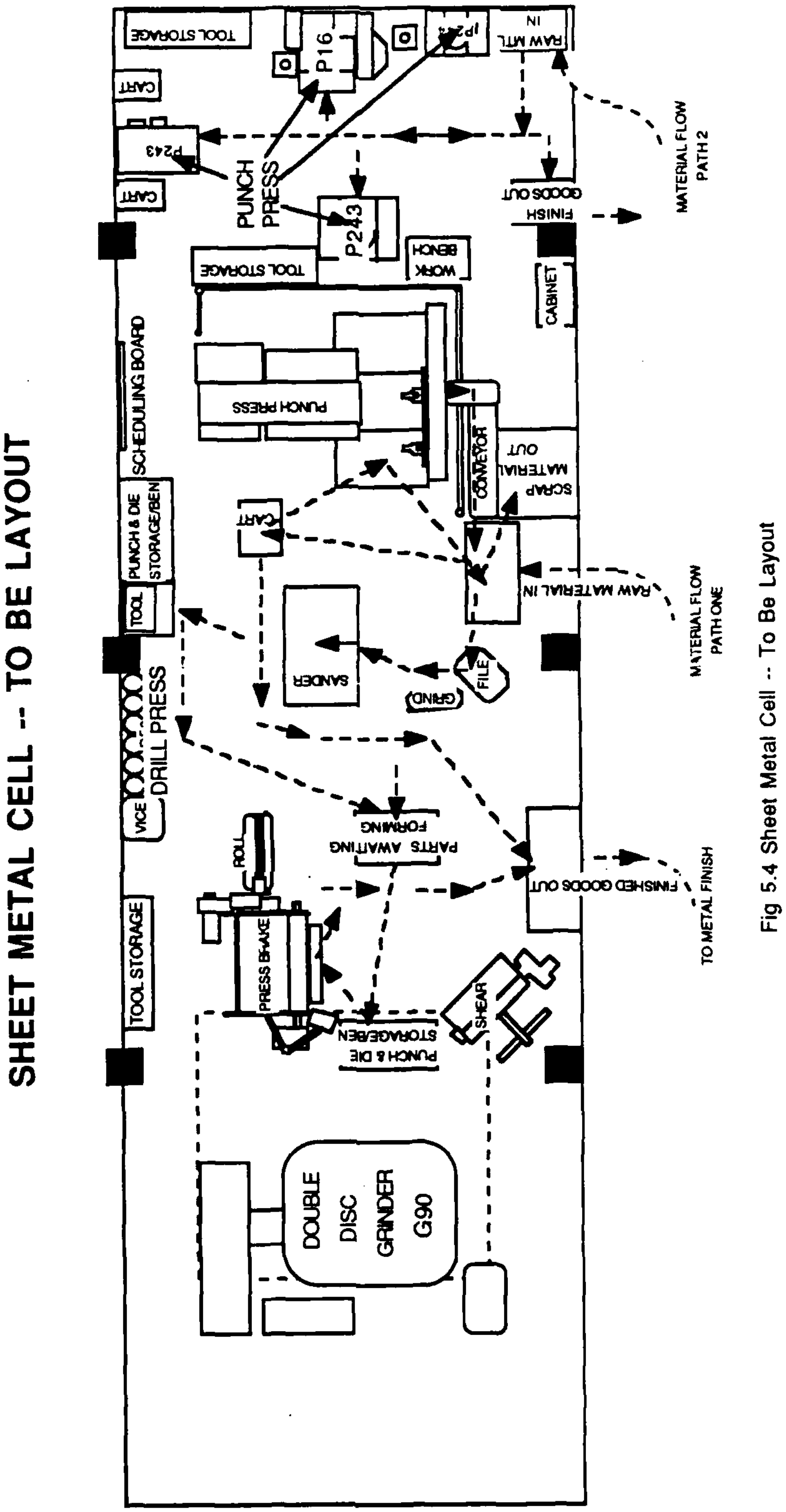


Figure 5.4 "To-Be" Sheetmetal Cell Layout and Workflow Diagram

The Production Engineer will determine which flow path each sheetmetal part will follow. The manufacturing process will give the flow path that is most economically feasible.

The decibel rating will be sharply reduced in the sheetmetal manufacturing cell by placement of acoustical tile on the walls and ceilings. High decibels created by the Punch Press and Air Press will be directed up into sound deadening material by a hanging strip plastic machine enclosure.

For personnel fatigue reduction, floor workmats will be placed at the Punch Press and Press Break where work is constantly being done in the standing position. All work surfaces will be ergonomically adjusted for heights.

This cell is designed to operate efficiently with 3 people per shift; a punch press operator, a press brake operator, and a hydraulic press/drill press operator. To meet the projected load, this cell will run two shifts.

SECTION 6

PROJECT ASSUMPTIONS

The following are the assumptions made for the Sheetmetal Cell:

- Inspection of all Punch Press work will be by first piece acceptance. Upon acceptance, process certification will occur, which constitutes no Flat Pattern storage on the factory floor.

- Design to Production Programming System integration will occur.

- One shift operation is based on 1700 standard hours.

- Labor classification changes will not infringe upon the present bargaining unit contract.

- The Sheetmetal Cell will be implemented second quarter of 1988.

- The floor space and capital requirements will be made available at the time of implementation.

- Volume projections are based on Test Systems and Logistics Operations (TSLO) 10 year forecast as the major sheetmetal customer.

- Short Run jobs of under 100 pieces per run will continue to be 80% of the workload.

- The design and operating capacity of this cell is contingent upon the forecasted volumes. The design structure of this cell will be replaced by new design requirements if the volumes increase/decrease out of its relevant range of measure.

SECTION 7

GROUP TECHNOLOGY CODING SYSTEM ANALYSIS

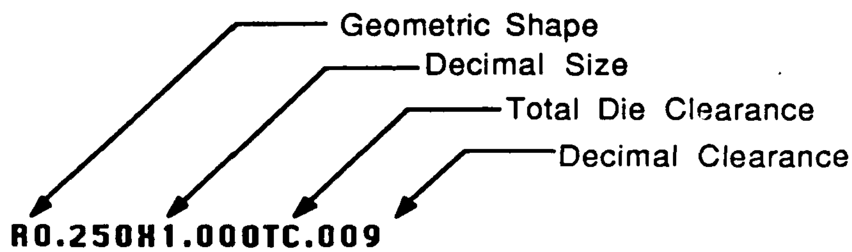
The Sheetmetal Manufacturing Cell was formed from the resultant group technology search of commonalties of part manufacturing features and volumes. For a more clear understanding of this search, Section 7 of the Project Overview should be referenced.

TOOL ORGANIZATION

Currently there are four different internal numbering systems that control punch press tooling.

- ATD, Arrow Tool Design.
- GPT, General Purpose Tooling.
- T#'s, Tooling that is project specific.
- Decimal size, geometric size and shape.

This numbering system creates the need to use cross reference charts to determine the tool's geometric size and shape, and to give drawer location. As a result, the numbering system is causing inefficient set-ups. A new numbering system has been developed which will allow tool organization by size and shape. Each tool number will describe the punch size by its decimal equivalency. An example is shown below for a rectangle punch and die. This number will be issued by the Production Engineering department. On all punches, the decimal size will be scribed or etched on tool surface for permanent identification. On all dies, the total decimal die clearance will be scribed or etched about its diameter. The CNC program will call out the punch and die in the format shown, allowing the operator to efficiently identify the required tooling. All tooling will be retrieved from storage cabinets that are organized by size and categorized by shape.



A new numbering system will:

- Eliminate the use of cross reference charts by operator.
- Allow the organization of tools by its number.
- Reduce set-up times.
- Be recognizable and compatible with the DNC programming system.
- Simplify tool ordering.
- Remove the need for tool drawings on rectangles, rounds, squares, and ovals.

SECTION 8

PRELIMINARY/FINAL DESIGN AND FINDINGS

Within the guidelines of the technical approach outlined in the main section of this report, the Sheetmetal Fabrication Cell was developed to its final design. The approach taken to derive the Sheetmetal Cell is outlined below.

A manufacturing measurement base was established on each piece of equipment in the Sheetmetal production area. From weekly production control load reports, standard run and set-up hours were tallied for a 10 month period beginning July, 1986. Hours were entered by week on a spread sheet under column headings of: number of jobs by machine, standard hour per job and set-up standard hour per job. Production standard hours were totaled and divided by total number of jobs to give an average standard run and set-up hour per job. The 10 month total was adjusted to give a standard total for a 12 month period on each machine.

The tool-room punch press load was not available on the weekly production control load report. To get that additional load, tool room job "close out" reports for a one year period were manually searched for all punch press work. Adding the tool-room load to the production load gave the overall load in standard hours. This became the sheetmetal measurement base.

Test Systems and Logistics Operations (TSLO) marketing department could only give projected percent increases in sales revenue. These projections were not project specific. Given this information, a percent increase in production jobs run per year was set by the percent of sales revenue increase. Volumes were set over a ten year period. The derived forecasted volumes were then used as design criteria for the Sheetmetal Cell's equipment selection, material flow concept, floor layout and utilization of equipment.

A thorough equipment technology search was conducted to determine the punch press that would best fit the cell. The technical publication entitled "The Fabricator" gave a matrixed comparison of all available CNC punch presses. The comparison was based on machine punching performance, punching capacity, tooling requirement, air usage, square foot requirements, power required and punching positional accuracy. The machine selected had to meet the following criteria: punching positional tolerance of ±.005", compatible with 112 Diacro/Weidemann tooling, 1500 rpm positioning speed, equipped with a Fanuc control, small footprint, 1/4 material thickness capacity, over 20 ton punching capacity, and could punch over 300 hits per minute.

The Tooling for the present punch press is compatible to the new CNC Punch Press selected. Three hundred jobs were randomly sampled out of an active job population size of 2000 to determine punch press tool usage. From these findings, punch holders for the sixty most frequently used punches will be procured. These tools are to be set-up permanently ready for use.

The machine feature of tool rotation within the turret will allow an average change of 1.5 tools per set-up. Positive alignment of line bored turrets will eliminate the operators need to center tooling clearances. A new tooling numbering system will be introduced. Each tool number will indicate tool size and geometric shape. Tool storage cabinets will be procured and all punches and dies will be organized by this numbering system. This system will eliminate the four different numbering systems and along with it, the operator cross reference charts. By tooling up for quick tool change over, organizing tooling by a new numbering system in efficient storage cabinets and using the tool rotation feature, set-up will be reduced 50%.

An inventory evaluation was taken on all existing material handling shelving, storage cabinet and work surfaces to assess furniture replacement or removal needs. It was found the punch press brake tool storage cabinets/racks did not allow organization of tooling. Replacement tool storage cabinets are necessary.

A CNC punch press program certification procedure was developed for flat pattern inspection. Flat pattern storage was necessary under the old inspection system. Certified programs allowed the removal of flat pattern storage in (3) 4-drawer filing cabinets and (2) large flat pattern storage racks. Also, removal of (6) material storage charts, (1) bench, (3) cabinets and a host of shelving allow for more efficient use of production floor space and material flow path. To address material in process storage needs, material for 3 days of production was tracked. The additional shelving required is as follows: (1) H48" X D30" X L48", (1) H60" X D30" X L72", (1) H48" X D30" X L36", (1) H36" X D30" X L60" including a maple work surface.

With the identification and selection of furniture and equipment, a preliminary floor layout was developed (see Figure 8.1). At this point, an informal meeting with factory operators, Production Engineers and the Department Supervisor of Sheetmetal production was held to discuss operational concerns. With the addition of a small part conveyor and rearrangement of equipment, further improvements in material handling were made. With the addition of a 25 inch timesaver straight-line sander, the final floor plan was developed. Figure 8.2 shows the final floor plan.

Sound ratings between 90 - 95 decibels made it mandatory for operator to wear hearing protection. It is projected the new Sheetmetal Cell sound ratings will be between 70 and 75 decibels. This 20 point reduction will result from placement of acoustical tile on the walls and ceiling. High decibels created by the punch press will be directed up into sound deadening material by hanging plastic-strip enclosures.

Based on the Sheetmetal Cell's final design concept and projected production loads, cell load, equipment utilization and manpower requirements were derived. The ten year production volumes were set for each machine. This was established from TSLO's projected increase in sales revenue. From the earlier described measurement base of run and set-up standard hours, production hours were totaled to give machine load by year over a ten year period. Machine utilization was calculated on each piece of equipment by dividing the total machine load by 3400 usable hours per 2 shifts. Manpower requirements were derived by dividing the total machine load by 1700 hours. From these finding, the sheetmetal cell will run efficiently with a total of 6 production operators, 3 per shift.

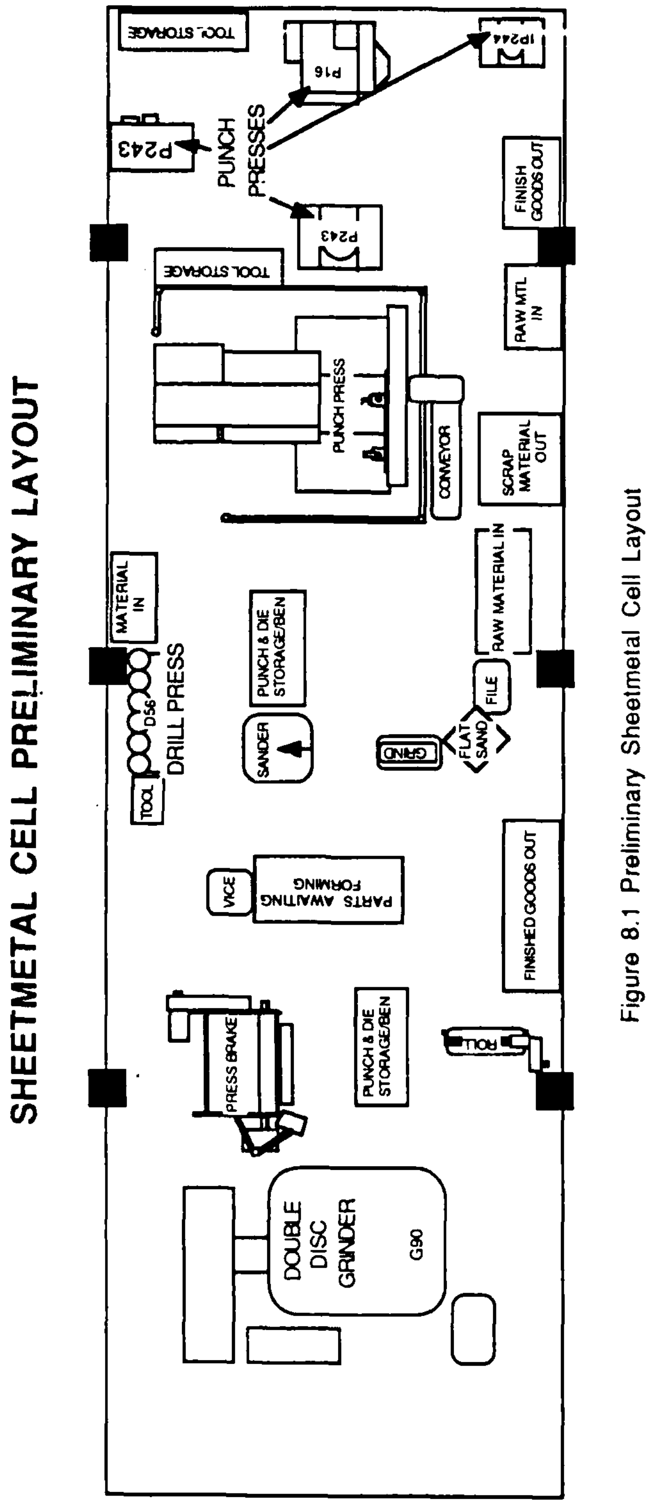


Figure 8.1 Preliminary Sheetmetal Cell Layout

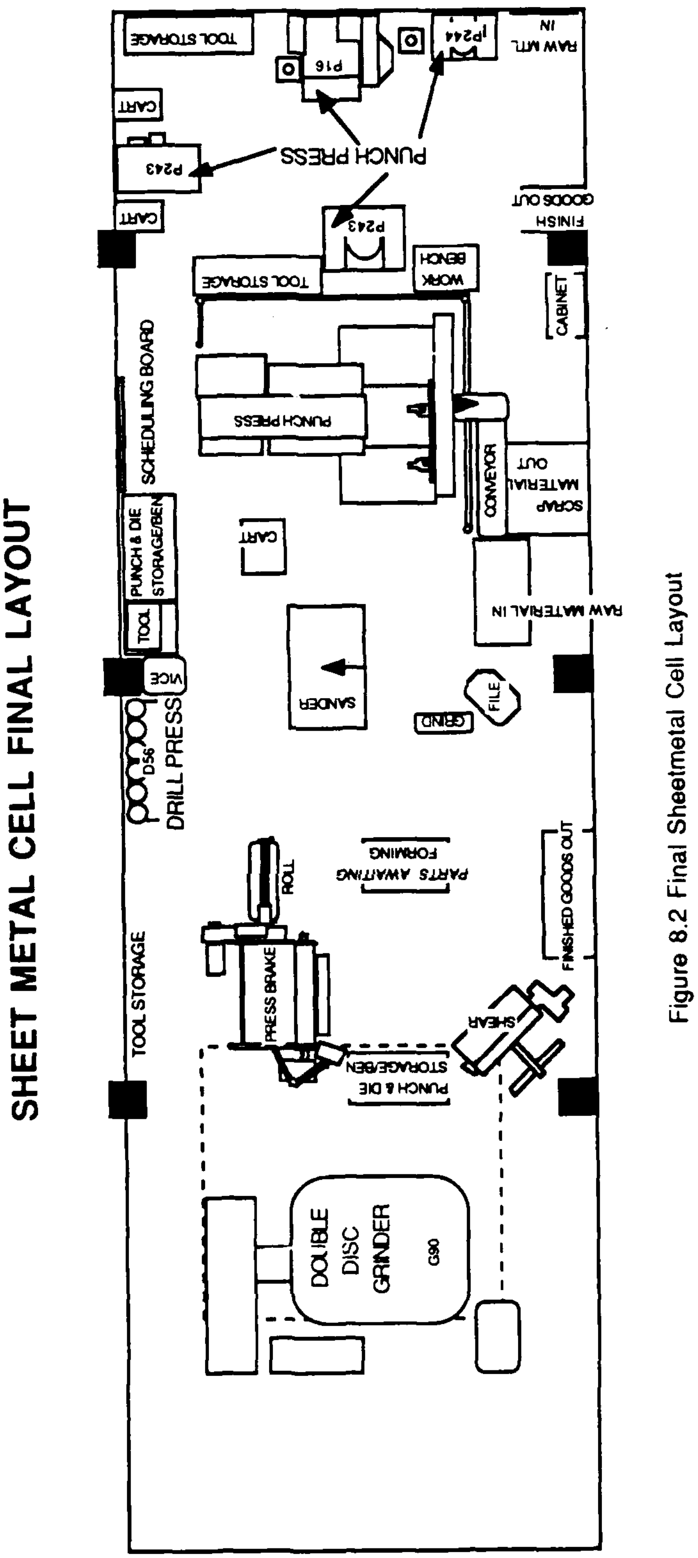


Figure 8.2 "To-Be" Sheetmetal Cell Layout

SECTION 9

SYSTEM/EQUIPMENT/MACHINING SPECIFICATIONS

The sheetmetal cell will need the addition of the following pieces of equipment to operate efficiently. The equipment specifications are listed below for each.

1. CNC Turret Punch Press

    - Weidemann Punch Press - Centrum 2000/Q
        - 112 or 114 style tooling
        - 22 Station Turret w/2 auto index stations
        - Turret rotation speed 25 rpm
        - Small parts auto-off-load chute
        - FANUC control model 6MB
        - Punching accuracy $\pm$ .005
        - Sheet capacity 40" x 48"
        - No foundation required

2. Straight Line Sander

    - "Timesaver" Wet Sander
        - Series 200 model 225 - CMW
        - 25" wide sanding belt
        - Variable oscillation of the abrasive brush
        - Air knife dryer
        - 35 durrometer contact wheel
        - 10" infeed conveyor extension
        - Mechanical digital readout
        - Motorized part thickness adjustment

3. 30 Degree Incline Conveyor Belt
    - 10" belt width
    - 12" bed width
    - Conveyor length 8 feet
    - Angle leg adjustments to 30 degrees

SECTION 10

TOOLING SPECIFICATIONS

TOOL SPECIFICATIONS

Replacement tooling for a CNC punch press will be made of A-2 5% chrome, air hardened tool steel. A-2 steel gives a superior shock and abrasion resistance which is tougher and more wear resistant than oil hardened tool steels. Total die clearance will be 10% of the material thickness for 5052-H32 half hard aluminum. Mild steels will require 15% total die clearance to effectively run at high punching speeds. 95% of all material currently punched is 5052-H32 aluminum between the thickness of .063 inches to .125 inches. To standardize on one die clearance, size tests will be run to determine this common size. A projected common total die clearance is .009 inches. This is 10% of the mean material thicknesses used. Shown in Figure 10.1 is a typical round punch, set-up into a tool holder with a matched die.

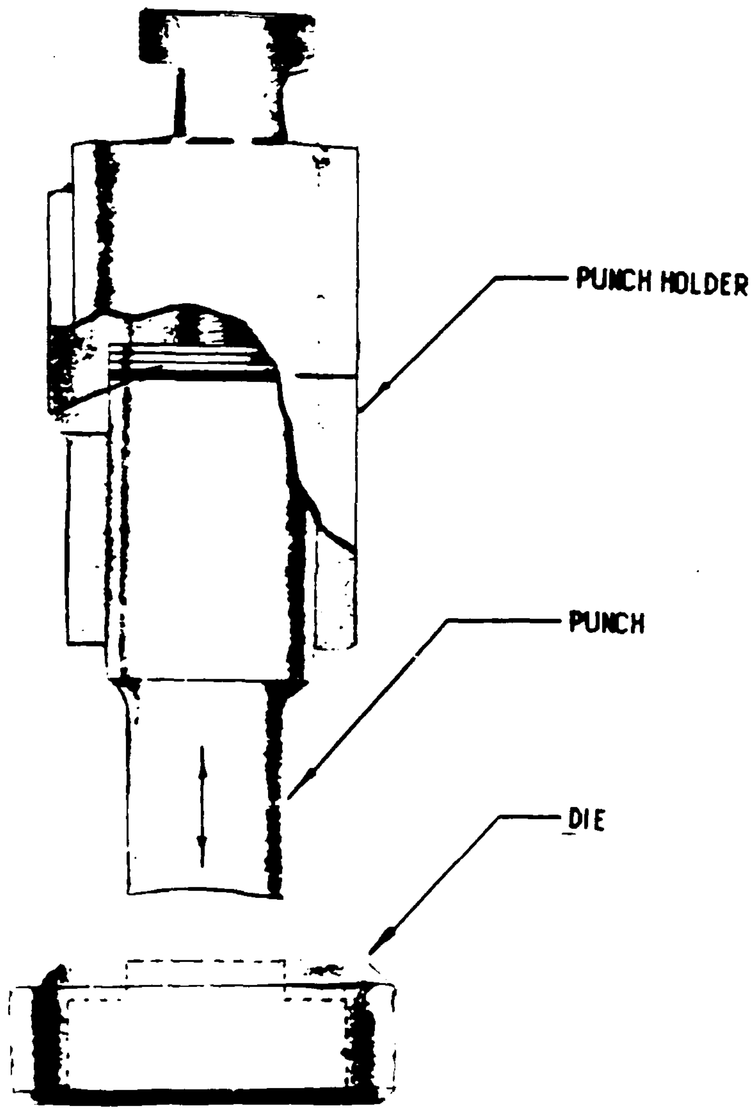


Figure 10.1 "To-Be" CNC Punch Press Tooling

SECTION 11

VENDOR/INDUSTRY ANALYSIS/FINDINGS

Throughout the world there are numerous machine tool builders and most of them are represented in the United States. Minneapolis, Milwaukee and Chicago are the major industrial machine tool suppliers of our region and they represent a well rounded cross section of all available equipment. Given this, an industry survey of our region was conducted to identify companies that are capable of supplying equipment that would meet the machine tool requirements of the sheetmetal cell. The selection for potential suppliers was based on the satisfaction of the following criteria (not listed by priority or importance):

- Prior Honeywell - vendor relationships.
- Dunn and Bradstreet status.
- Machine requirements and capabilities.
- On site visits.
- Project support in supplying pertinent data.
- Capability to deliver.
- Price.
- Servicing and training support.

Although tool cost, which reflects both the price of the equipment and its durability is important, it is not necessarily the paramount criterion. What is paramount, depending on objectives, is either minimum total cost of the machining operation or maximum production rate. Equipment utilization is very high because the machine tooling necessary to produce the parts are in one location while one operator runs multiple machines for optimum productivity.

The seven potential suppliers selected to bid on the proposed project are:

- C & S Sales, Brookfield, WI - Representing Sommer & MACA.
- The Warner and Swasey Comp. - Weidemann Div.
- Productivity Inc, Minneapolis, MN - Representing Trumpf.
- Concept Machine Comp., Minneapolis, MN - Representing Finn-Power.
- Strippit Houdaille, Inc.

- Slicer - Machine Rebuilders, Minneapolis, MN.

- Abrasive Systems Inc., Minneapolis, MN - Representing Time Saver.

For the Sheetmetal Cell, the new equipment required is one CNC punch press and one 25 inch straight line sander. Equipment suppliers were identified by the use of Thomas Registers, Honeywell Procurement Department and prior departmental contacts. The suppliers were given the needed machine tool requirements. It was asked that these vendors give time estimates, price quotes and detailed equipment specifications for evaluation. After receiving quotes and data on each piece of equipment, a comparison of machine performance, price and floor space required was made. Tooling compatibility and maintenance needs was measured. As a result, the following equipment and vendors were chosen.

- Weidemann CNC Punch Press Model Centrum 2000/Q.

  This machine was selected because the current tooling used is fully compatible. The machine's features of programmable tool rotation in two stations of the turret, punching accuracy, small parts conveyor, and impressive punching speeds had the largest impact on set-up and standard hour reduction.

  The vendor supplying the Weidemann punch press is:

  The Warner & Swasey Company
  Weidemann Division
  Minneapolis, MN.

- 25 inch series 200 wet "Time Saver" sander

  This machine was selected for its ability to deburr parts by giving quality radiused edges and through holes while maintaining a mat finish. This is a wet sanding process and will not emit particulates into the air.

  The vendor supplying this sander is:

  Abrasive Systems Inc.
  Minneapolis, MN.

SECTION 12

EQUIPMENT/MACHINERY ALTERNATIVES

If for any reason the primary equipment selected for this Sheetmetal Fabrication Celi will not be available upon implementation, a similar machine of the same magnitude, but not necessarily of the same manufacture will be provided. This may include:

CNC Punch Press

Alternative 1:

- Vendor: Concept Machine, Minneapolis, MN.
- Machine: Fin Power
- Model: TP-250 F2

Alternative 2:

- Vendor: Productivity Inc., Minneapolis, MN.
- Machine: Trumph
- Model: Trumatic 185

The two machines were selected as an alternative because of their high punching accuracy and its ability to give optimum tool life. The machine performance is comparable to the Weidemann but the tooling would not be compatible. The cell's material flow would have to be redesigned if this model was purchased.

Straight Line Sander

- Vendor: C&S Sales, Brookfield, WI.
- Machine: Sommer & Maca
- Model: Somaca Wet Deburring Machine FSD-6362

This machine was selected as an alternative because of its use of "scotch-brite brushes" in a wet solution. This would slightly radius edges and holes but would require high maintenance. Operators would need to control brush wear by feeding bush rollers equally.

SECTION 13

MIS REQUIREMENTS/IMPROVEMENTS

The Distributed Numerical Control (DNC) programming system (proposed in Project 44) will be on-line with the cell's CNC punch press. All operator and engineering changes, program updates and modifications will take place from the programming center. The digitized information will be transferred via a hard wired RS-232 connection. Active programming data will be sorted on hard drive memory which can be directly down loaded to the machining center. All information necessary for set-up and run operations will be accessible through the CRT linked to the programming system. This will eliminate all paper operation detail sheets needed to run the punch press.

The Sheetmetal Cell will interface with the Honeywell Manufacturing System (HMS), and Factory Data Collection System (FDC) without modification to other system hardware or software. A complete discussion of this topic is available in Section 13 of the Project Overview.

SECTION 14

COST BENEFIT ANALYSIS/PROCEDURE

OVERVIEW

The Sheetmetal Cell encompasses a large range of flat metal fabrication. The main focal point for CBA calculations was based on savings related to the reduction of Numeric Controlled (NC) punch press hours due to the high quantity and variety of parts processed through this cell. The average time per job was used to calculate savings. This average time was broken into the production run time and set-up time. The cost drivers were identified using the methodology shown in the process diagram of Figure 14.1.

MANUFACTURING SCHEDULE

The current year's job order volume from the weekly Production Control Load Report was used as a basis for establishing the Sheetmetal's manufacturing schedule. To that volume, Industrial Engineering applied a percent increase to derive the ten year volume projections.

This yearly percentage increase was generated by factoring the amount of Sheetmetal business by operation (IIO, FSO, TSLO) to the respective yearly percent change of each operation's revenue plan projections.

ACTUAL STANDARD HOUR SAVINGS

The "As-Is" baseline for the Sheetmetal Cell was established on sub-contract vendor quoted prices. A sample size of 70 part numbers was collected and analyzed to derive an average cost per production order.

The same sample of 70 parts was used to calculate the "To-Be" average internal (in-house) cost per production order. Individual time standards were first developed for each part number, then a "make or buy/sourcing" program was used to generate the "As-Is" and "To-Be" cost. To maintain a comparable baseline, the same quantity of parts per order quoted was used to calculate the "To-Be" cost.

A computer program was developed to compile and establish average cost per production order for both the "As-Is" and "To-Be" cost comparison. Calculating these averages against the projected job order (production) volume increases, the generation of savings was derived for this cell.

CAPITAL AND EXPENSE

The capital, recurring and non-recurring expense for the Sheetmetal Cell are shown in Figure 14.2.

COST BENEFIT ANALYSIS METHODOLOGY

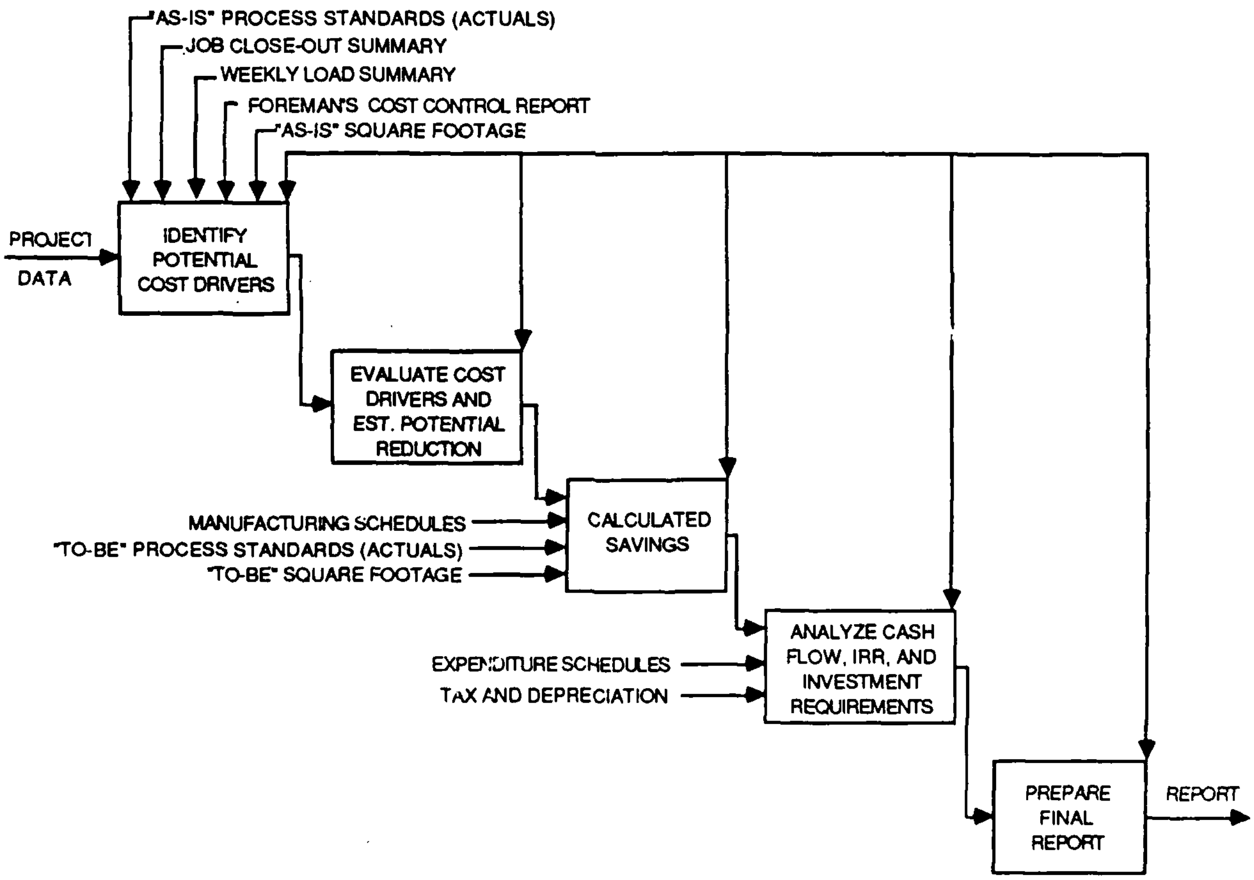


Figure 14.1 Sheetmetal Cost Benefit Analysis Methodology

SHEET METAL CELL
EXPENDITURE SCHEDULE

	Cost	Capitalization Date
CAPITAL COSTS		
MACHINERY COSTS		
** CNC Punch Press	$244,370	1988
** 25" (225-M) Timesaver Sander	$66,787	1988
** 10" x 8' Incline Conveyor Belt	$2,412	1988
** Tooling (Purchased)	$13,398	1988
TOTAL MACHINERY COSTS	$326,966	
FURNITURE COSTS		
** N/C Hydraulic Lift Cart	$536	1988
** Punch Press Tool Storage	$2,680	1988
** Press Brake Tool Storage	$2,010	1988
** Drill Press Tool Storage	$469	1988
** Acoustical Tiles and Sound Barriers	$5,825	1988
** W.I.P. Storage Shelving	$2,947	1988
TOTAL FURNITURE COSTS	$14,466	1988

TOTAL CAPITAL COSTS	$341,432	1988
EXPENSE COSTS		
NON-RECURRING EXPENSES		
Area Preparation Labor (HI)	$20,000	1988
Training (HI)	$2,000	1988
Process Development Direct Labor	$30,000	1988
Installation of Sound Barrier Labor	$2,000	1988
Post Processor Development Direct Labor	$2,000	1988

TOTAL NON-RECURRING COSTS	$56,000	1988
TOTAL CAPITAL + NON-RECURRING	$397,432	
RECURRING EXPENSES		
* Process Development	$1,000	

TOTAL RECURRING	$1,000	

* Expense starts in year 2.
** Costs contain a 15% contingency

Figure 14.2 Sheetmetal Cell Expenditure Schedule

PROJECT SAVINGS AND CASH FLOWS

The savings to be realized by this cell exceed Honeywell's Military Avionics Division hurdle rate. The cell's cash flows are shown in Figure 14.3 with the assumption that capital is available per the implementation plan.

TECH MOD PHASE 2

PROJECT 44 -- SHEETMETAL CELL

PROJECT CASH FLOW SUMMARY
($000)

	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	TOTAL
Capital	$341.4	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	$341.4
Non-Recurring Expenses	$56.0	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	$56.0
Recurring Expenses	$0.0	$0.0	$1.0	$1.0	$1.0	$1.0	$1.0	$1.0	$1.0	$1.0	$1.0	$9.0
Total Savings	$138.9	$554.3	$614.5	$743.6	$875.0	$935.7	$992.4	$1,057.9	$1,127.5	$1,199.4	$950.6	$9,189.9
Depreciation	$33.3	$60.1	$48.3	$38.9	$31.3	$25.3	$20.5	$23.2	$23.2	$23.2	$14.0	$341.4

Figure 14.3 Sheetmetal Cell Cash Flows

SECTION 15

IMPLEMENTATION PLAN

The implementation of the sheetmetal cell is scheduled for January 1988, with the inventory of all tooling. Rearrangements (described below) will occur in its corresponding numbered sequence. Figure 15.1 shows the time line in which the events are to start and finish.

1. Take complete inventory of all punch press and press brake tooling.

2. Color code all press brake dies by radius.

3A. Re-number all punch press tooling using the new numbering system.

3B. Complete wall mount display and drawer tags per punch size.

3C. All Aero Tool Design (ATD), General Purpose Tooling (GPT) and Tooling (T) numbered tool drawings must be simultaneously revised with 3A above.

4. Determine new tooling/replacements for discarded tools.

5. *Return all items that are job specific* to Tool Crib storage for use as jobs require.

6. Surplus all unused shelving, carts and cabinets.

7. Move double-disk grinding wheels.

8A. Move brake tool storage.

8B. Move brake work bench.

9. Move press brake (PB5).

10. Move flat pattern storage (3 template cabinets and 2 additional filing cabinets).

11. Relocate six foot punch and dies.

12A. Move (P16) air/hydraulic press.

12B. Move (PD56) drill press.

13A. Move Sheetmetal Roller.

13B. Move P243 when Sheetmetal Roller moves.

SHEET METAL CELL
IMPLEMENTATION SCHEDULE

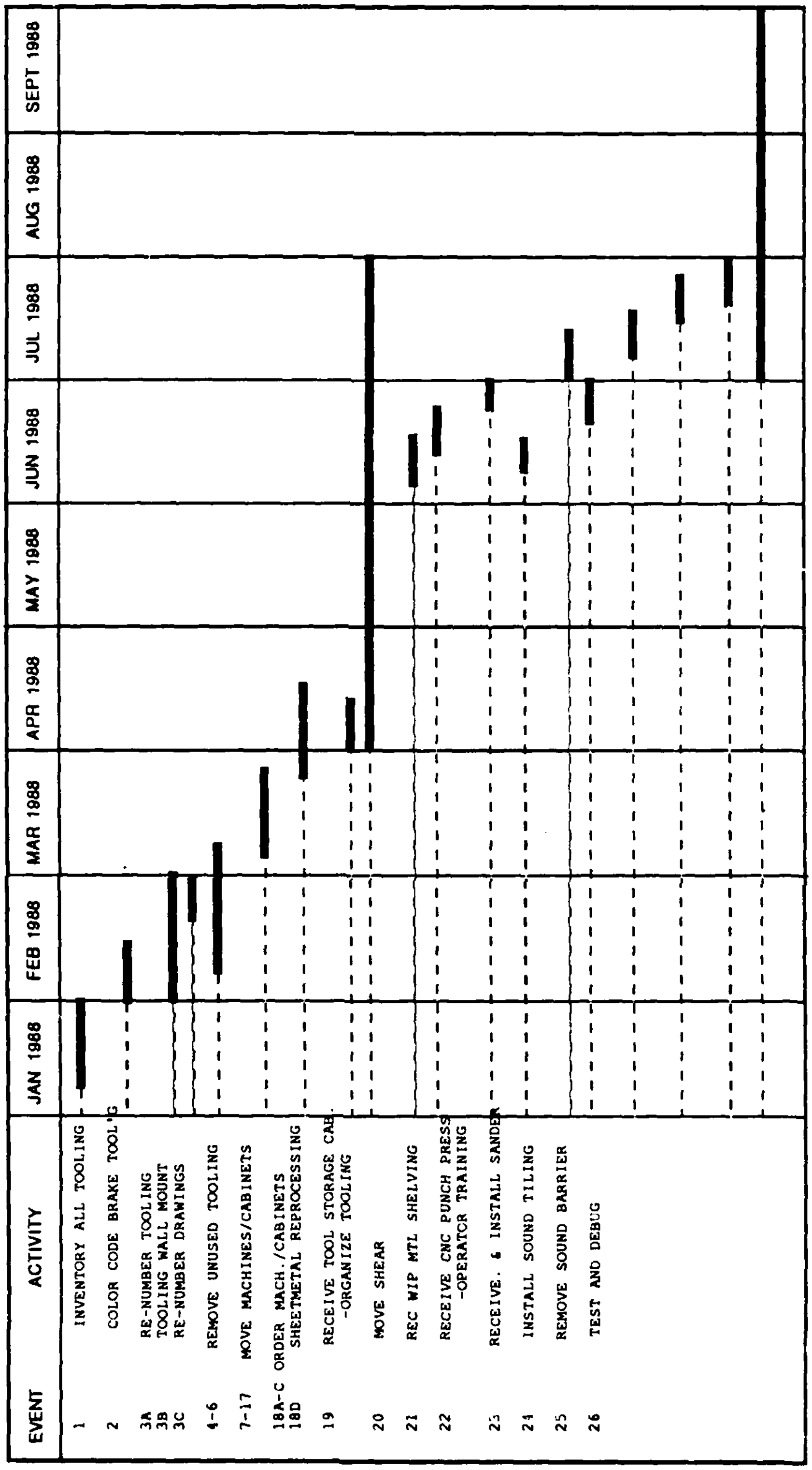


Figure 15.1 Sheetmetal Cell Implementation Schedule

14. Move hydraulic press tool storage.

15. Move (P244) hydraulic press.

16. Move die set storage - complete.

17. Re-locate (P273) hydraulic press.

18A. Order Work-In-Process storage shelving, tool storage cabinets and carts.

18B. Order CNC punch press, 25 inch wet sander and 30 degree incline conveyor belt.

18C. Order DNC terminal and coaxial cable.

18D. Reprogram sheetmetal parts sequenced by production control delivery schedules.

19. Receive tool storage cabinets and organize tooling.

20. Move shear.

21. Receive position Work-In-Process material handling shelving.

22. Receive CNC punch press and train the operators.

23. Receive and install "Time Saver" sander.

24. Install hanging plastic machine enclosures

    - Install acoustical tiling.
    - Check decibel levels.

25. Remove sound barrier wall.

26. Test and debug Sheetmetal Cell.

SECTION 16

PROBLEMS ENCOUNTERED AND HOW RESOLVED

Problem

One proposed method to reduce punch press tool set-up time was to establish a list of most frequently used tooling. This common tooling is to be set-up permanently which will allow quick tool changeover for common tooling. The problem was to establish a reliable list of the most frequently used tools.

Solution

The best way to retrieve this information was to manually extract punch use from active sheetmetal set-up detail sheets. The sample size taken was 300 active sheetmetal jobs. The production floor operators collected 200 production set-up sheets as they ran, and in parallel to this, a production engineer randomly sampled an additional 100 jobs in Document Control. All punches were listed and tally marks were recorded by each punch as it was identified on the set-up sheets. This gave a frequency of use by punch size.

SECTION 17

AREAS FOR FUTURE CONCERNS/DEVELOPMENT

CONCERNS

The current NC punch press is rapidly wearing in the turret and X, Y table slides, this directly affects positional location tolerances. If the machine becomes decertified, the current sheetmetal manufacturing area will be shut down until implementation of this cell occurs.

DEVELOPMENTS

Robot

The addition of a 3 axis robot with suction cup end effectors can load, unload the CNC punch press. Within the robot's work envelope, material will be stored in 36" X 48" sheets as received from the vendor and shelved in one vertical column for immediate use. After the parts are punched out the robot will remove the unused metal from the punch press and drop it in the scrap bin. By using larger sheets of aluminum, more parts per sheet can be produced, thus minimizing material handling and maximizing productivity. The robot and punch press will be integrated by a Gould 884 or an Allen Bradley 3/15 Programmable Logic Controller (PLC). By adding bending pressure sensors to the PLC, formed angles can be accurately controlled. From this information, stops can be set for multi-bend forming operations, thus eliminating repetitious set-ups. The DNC programming system will store the press brake pressure and bending settings for reuse on future production runs.

Automated Chromate Line

After aluminum parts are fabricated, it is proposed that these parts travel by conveyor to an automated chromate line in small batches. The chromate line should be isolated in an enclosed room within the pallet/laser base cell area. This line also needs to be located adjacent to the metal finish department where chemical storage, waste treatment and manpower may be shared. The main purpose of this chromate line is to chemically treat aluminum parts (die cast, solid and sheetmetal) cost effectively in small batches. The proposed location allows very efficient post metal finish material flow through installation of sheetmetal fasteners and final audit. By linking the chromate line to the sheetmetal cell this area becomes a complete manufacturing center with the flexibility to produce low or high volume products from raw material into finished goods.

Some potential problems and proposed solutions are:

1. Strong acids located close to machines.

   a) Castings would be purchased already pickled to eliminate two acids from the system.

2. Ventilation of the area.

   a. Two room temperature acids are needed in the chromate machine. System will be well ventilated, and the line would be enclosed to control air movement.

   b. A second exhaust system using an alternate source of power, would be installed to maintain a negative pressure at the machine if primary power fails.

3. A great variety of sizes and shapes of parts are involved which complicates the rinsing and draining.

   a. Universal rack is not deemed feasible, so a number of rack designs will be needed, some specific to individual parts and some specific to a general size and shape of parts. Racks will be hand loaded by an operator.

   b. Manual spray rinsing will be incorporated at some rinse stations.

4. Acids and chromate chemicals need to be regulated for sewer introduction.

   a. For chromate, a dragout rinse is included, and that rinse plus any batch dumps would be transferred by permanent pipe to the waste treatment area of the plating shop.

   b. Acids will be water jet aspirated through a permanent pipe to the same waste treatment area.

5. Two classes of chromate (1a and 3) are used on our parts.

   a. It is possible and quite common to draw both classes of chromate from the same process by using a proprietary chromate chemical that is approved for both classes.

The chromate line would be made up of 12 process tanks, a load station, an unload station and a dry station. The process tanks would be: one solvent degrease, one flash off, one alkaline clean, two acids, one chromate, five rinse and one hot deionized water spray. The rack transport would be by means of an automatic hoist traversing a straight line track in the method commonly used by the plating industry. The rack transport is computer controlled, with storage capability for eight process cycles.

It is projected that this chromate line will fit in an area 20 X 46 feet in size with the length and width of the machine, including load, dry and unload stations, dictating the shape of the area. It is further projected that the optimum arrangement would have a dry station off of the automatic machine, with a means of transporting racks to a separate conveyorized dry unit that moves racks to an unload station and permits some stacking of racks.

These concepts have been discussed and will be investigated in detail when the proposed cell has been installed. The benefits derived from this system would mean additional reductions in labor costs and improvements in material flow.

An extensive investigation was done on a cost analysis to determine if such an automated system could be justified. With the current volumes of the selected parts in this cell, a good return could not be accomplished. A decision was made to use the existing Metal Finish Department chromate area for finishing these parts. The parts could still be shuttled between work centers by means of stores personnel or the automatic wire guided vehicle (AGV) system that is planned for in Project 21. If the part volumes increase, this concept would be a viable addition to this cell. With the proposed "To-Be" layout, this chromate line would easily be incorporated into the Sheetmetal Cell and the Pallet Cell in the future.

PROJECT 44

PALLET CELL

SECTION 1

INTRODUCTION

Many devices manufactured by the Military Avionics Division of Honeywell are assembled into packages that form a group of components produced by the Fabrication Facility. This group of components are of various configurations with similar process commonalties. These parts are made up of aluminum stock or aluminum castings. The average size is approximately six cubic inches and vary in tolerance from ± .005 inches. With this variety, and the projected volumes for this group of parts, a cellular manufacturing approach was encouraged. The driving elements of this approach are the reduction of costs, reduction of lead times, positive material control, reduction of inventory, better quality and production flexibility.

A manufacturing cell containing three palletized machining centers, equipped with CNC capabilities, proved to be a correct selection of the available technologies. Therefore, it is called the "Pallet Cell". This ceil addresses machining of castings and forgings.

SECTION 2

PROJECT PURPOSE/OVERVIEW

The objective of the "Pallet Cell" is to provide a state-of-the-art, flexible, general purpose machining center and a material handling system that will support Fab Fac's high variety, low volume manufacturing conditions of today.

The "As-Is" processes for these components were gathered and thoroughly analyzed. The sequence of some operations were rearranged and process method changes were introduced that resulted in a reduction of cost. This methodology established a basis for the "To-Be" process

With this cellular manufacturing approach, the following benefits were achieved: reduction in cost, reduced lead time, minimum Work-In-Process (WIP) inventory, more effective material handling, effective material control and flexibility to meet customer demands.

SECTION 3

TECHNICAL APPROACH

In defining the Pallet Cell, an immense amount of product mix, part families, manufacturing volumes, labor costs, systems, software and fixturing had to be researched and analyzed to determine the final design requirements. In this analysis the following approach was taken to develop and integrate this cell.

DETERMINE DESIGN REQUIREMENTS

Defining part families was the first step in selecting the work to be run in this cell. The parts selected were castings and forgings which required milling, drilling, tapping and boring. The present process was the basis for our "As-Is" condition and was used to establish the base for the CBA. This group of parts were thoroughly analyzed, operations rearranged and process changes introduced that resulted in a reduction of cost. With this methodology a "To-Be" approach was established. At this point, the information was analyzed and consolidated into a project matrix.

DEVELOP ALTERNATIVE CONCEPTS

Alternative concepts and suitable locations in the Stinson/Ridgway facility were considered in order to meet the requirements of this cell. These concepts included an automated chromate line, overhead conveyor system, tool monitoring system, in-cycle gauging and a pallet shuttle table. These concepts were formulated and developed into a system arrangement using data compiled from a cell simulation study and material work flow analysis. These concepts are discussed further in the Preliminary/Final Design section of this report (Section 8).

EVALUATE ALTERNATIVES

The alternatives were evaluated based on criteria from equipment searches, floor layout, capacities, costs, savings and technical feasibility.

SELECT THE BEST LAYOUT CONFIGURATION

After a preliminary design was selected, a team was established to further develop the concepts, layout requirements and system configuration that would best suit this cell.

DEVELOP A FINAL DESIGN

With the information derived from the preliminary design, a formal layout and system configuration was developed and finalized for the Pallet Cell.

SELECT EQUIPMENT SUPPLIERS

An industry survey was conducted to identify the companies capable of supplying the equipment needed to satisfy the requirements of this cell. The following criteria was taken into consideration: capability to deliver, pricing, servicing, financial stability (Dunn & Bradstreet ratings) and equipment capabilities. All the selected companies were asked to supply bid packages.

REVIEW AND EVALUATE RESPONSES

Responses were received and evaluated based on equipment specifications, service history, cost, equipment configuration and system operation.

EQUIPMENT SELECTION

A final evaluation of the bid packages was made and a vendor selected. Vendors with specific equipment were asked to run sample parts to verify that the equipment could produce the anticipated results.

FINALIZE DESIGN

Based on the final vendor selection, a final layout and specification was prepared and an implementation schedule determined.

PREPARE COST BENEFIT ANALYSIS

With all the cost preparation complete, a final cost benefit analysis was prepared showing projected savings, expenses, and return on investment. To monitor these results, a plan was established to determine the actual results after implementation.

SECTION 4

"AS-IS" PROCESS

INTRODUCTION

With the present system of manufacturing, the components that flow through the Pallet Cell follow a single disciplined, batch type operation philosophy. One machining operation is performed on a piece of equipment, and transferred (through stores personnel) to the next sequential operation, until the final operation is reached. With this type of discipline, the following inefficiencies are present in an "As-Is" operation: undesirable material flow, poor productivity, low utilization, excessive lead times, excessive Work-In-Process (WIP) inventory, complicated process requirements, unorganized facility layout and lack of an effective quality control. These elements are described below.

MATERIAL FLOW AND MATERIAL HANDLING

The parts identified and their operations for this cell follow a complex flow through the shop. They are fabricated partially by one department and moved between the departments according to layouts or process sheet instructions. With no centralization of these work areas, parts are often moved from one end of the Fabrication Facility to the other with long delays, large staging areas and long delivery schedules. These conditions cause difficulties in material control and material handling. Refer to Figure 4.1 for the "As-Is" material flow and Figure 4.2 for the "As-Is" Milling workflow.

PRODUCTIVITY AND UTILIZATION

The "As-Is" process methods of the milling area contain many general purpose machining operations and very little dedicated equipment. As the operations on the parts are completed, they are routed from machine to machine until the final operation is reached. For each piece of equipment, this involves the same disciplines of schedule, run, tear down, and reschedule. These conditions result in excessive set-up costs, poor productivity and low utilization.

LEAD TIMES

The present arrangement (Figure 4.1) of the manufacturing resources in the milling area cause excessively long lead times and undesirable Work-In-Process inventories. This is created by manufacturing operations being scattered throughout the shop. In some cases lead times reach 397 days. Figure 4.1 shows how the various operations are scattered throughout the department. Many shop delays occur due to inefficient job processing procedures. This approach also reduces and delays the response to any customer demands.

PALLET CELL
MILLING AREA LAYOUT -- AS IS

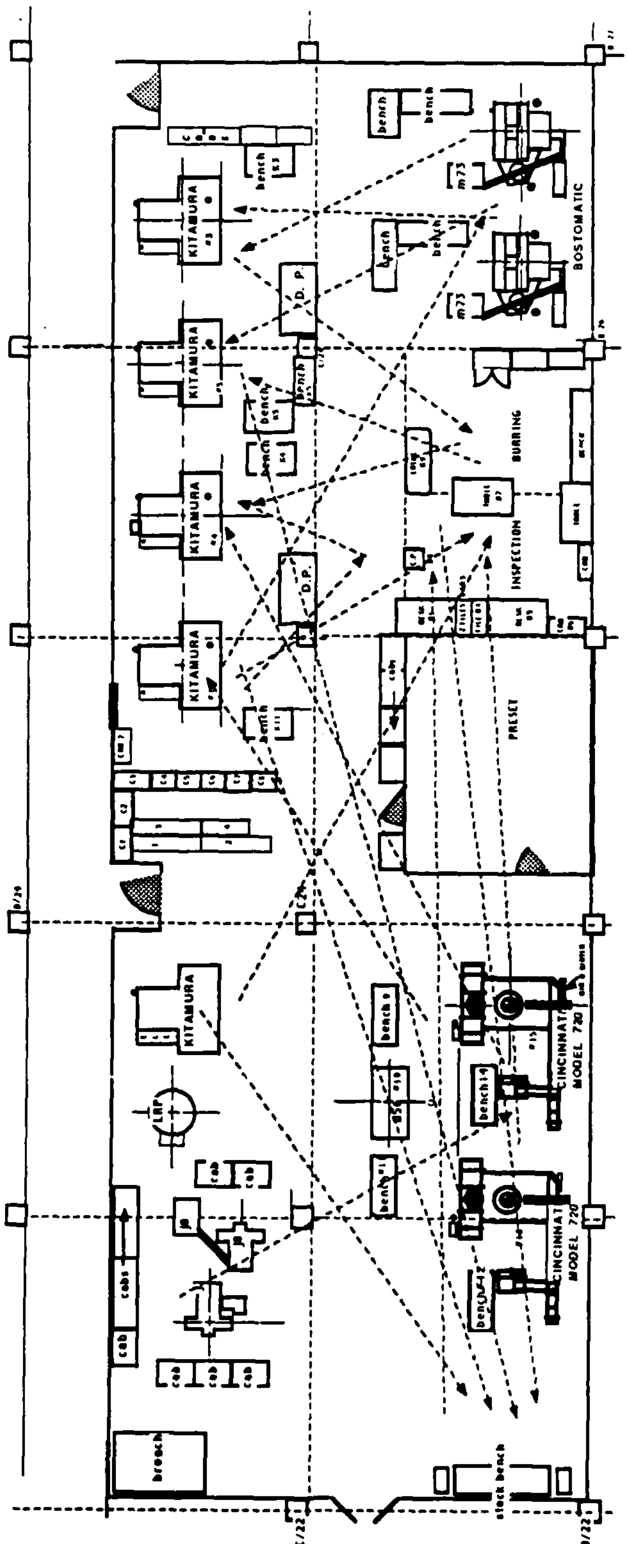


Figure 4.1 "As-Is" Milling Area Layout and Material Flow

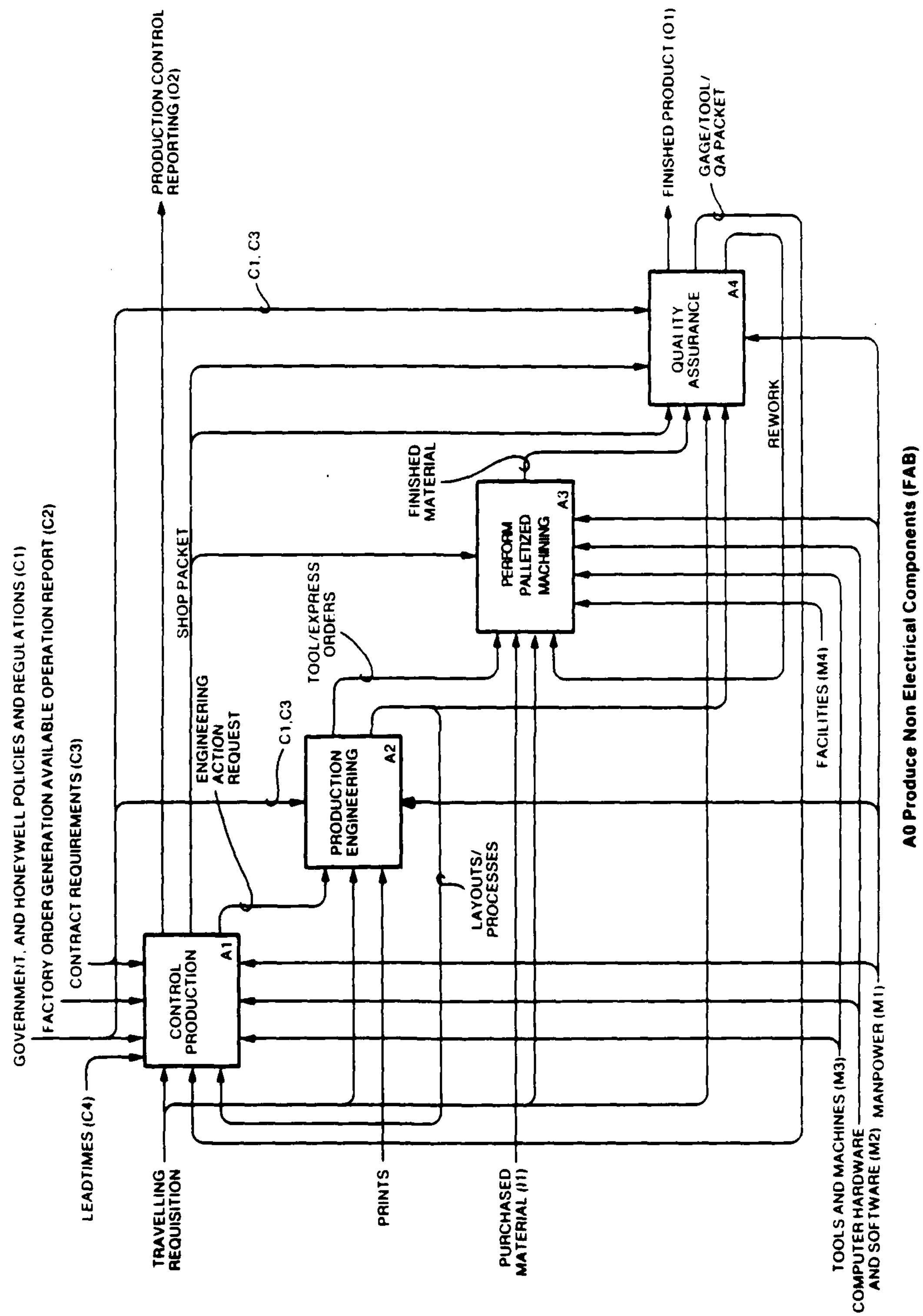


Figure 4.2 "As Is" Milling Workflow Diagram

EXCESSIVE WIP INVENTORY

As mentioned above, the present type of manufacturing creates a push type batch processing operation which generates an excess amount of WIP inventory in front of the machines.

PROCESS REQUIREMENTS

Under the present conditions in the NC milling area, parts follow complicated process requirements. They follow a single discipline, batch operation philosophy. All configurations of parts with different characteristics are run in this traditional approach. Everything from short run to moderate volume parts are mixed and grouped in this department. Short run and moderate volume loads are respectively defined as 20 and 500 parts per job. With this approach, large staging areas for fixturing, tooling and parts are created causing an undesirable material control situation.

FACILITY LAYOUT

The Fabrication Facility is divided into five departments. One of these segregated departments is the NC milling area. The components making up this area are presently being processed on equipment scattered throughout the department. The material flow illustrated in Figure 4.1 shows how these disciplines strongly highlight the inefficiencies within the present layout configuration.

QUALITY CONTROL

As parts are machined, they are routed from machine to machine until an inspection operation is reached. The parts are then brought into the inspection staging area to be assigned a priority for inspection. After completion of inspection, parts are routed through the subsequent operations until another inspection operation is reached. If the parts are rejected at an inspection operation, and must be reworked, they are routed back to the milling group for rework. This causes additional delays due to interrupted scheduling.

SECTION 5

"TO-BE" PROCESS

INTRODUCTION

The proposed Pallet Cell is an integrated manufacturing system consisting of equipment dedicated to support the machining of forgings and castings. This equipment consists of three palletized CNC machining centers, two horizontal spindle CNC machining centers, three vertical spindle CNC machining centers, an insertion/stake bench area, two coordinate measuring machines and a pallet shuttle system. With this cellular structure, the following elements are the major drivers of this "To-Be" approach:

- Process requirements.
- Material flow and manual material handling.
- Facility layout.
- Quality control.
- Intangibles.

PROCESS REQUIREMENTS

The palletized cell concept applies to a high mix, low to moderate volume (20 to 500 parts/order) production environment. It integrates a group of flexible general purpose machines and tools that utilize a common pallet design with parts pre-fixtured onto the pallets. This project concept insures the timely manufacture of the major components dedicated to this cell. The tools and fixtures will be permanently dedicated to each machine. With the equipment having permanent tooling, most of the set-up costs would be eliminated. To change from one job to the next could be accomplished by reading in a new program and indexing to the new fixture pallet. With tooling permanently set up in the machine, jobs can be cost effectively produced in lot sizes of one piece.

The Numerical Control (NC) programmer will prepare computer assisted machining programs. These programs will be down loaded into the cells computer via a Distributive Numerical Control (DNC) link. The pallets are coded individually to represent one particular part. When the pallets are in the ready to machine position, the machine reads the code and then asks the cells computer for the proper program. The cell computer will output additional instructions, both graphic and text, to the operator via the operator's input terminal. The cell computer will monitor production rates, machine run time, and time on each cutting tool. The machine run time will be tracked for maintenance schedule and machine utilization. Monitoring cutting time will alert the operator to change tools.

Using this cellular approach, machine utilization, material flow, and throughput will be increased. Set-up will be reduced and scrap and salvage will be controlled to manageable limits.

MATERIAL FLOW AND MATERIAL HANDLING

The formation of this cell and system arrangement simplifies the material flow and reduces the total part travel distance within the cell. Material is moved within the cell area by material handling personnel or the group leaders assigned to the area. This is accomplished with manual hand carts or shop personnel. As described above in the process requirements, with set-up being negligible, its easier to respond to customers schedule demands. Lot sizes can be sized to meet delivery requirements. Figure 5.1 shows the equipment layout that is proposed for the cellular approach. With this arrangement, the parts will be machined complete prior to leaving each cell. The cell has the flexibility to meet any type of schedule demand from the product line. Other benefits include reduced WIP inventory and the ability for production control to respond quickly to any unplanned schedule changes. Figure 5.2 represents the work flow for this concept.

FACILITY LAYOUT

The "To-Be" layout is a result of the rearrangement of the Fab Fac area to support a group of dedicated parts. This was accomplished by analyzing the manufacturing flow paths for each operation in the cell. The flow paths were equipped with an adequate amount of equipment to satisfy the requirements of the parts. The formation of this cell localizes the manufacturing operations into a smaller area. Figure 5.1 represents the "To-Be" cell layout.

QUALITY CONTROL

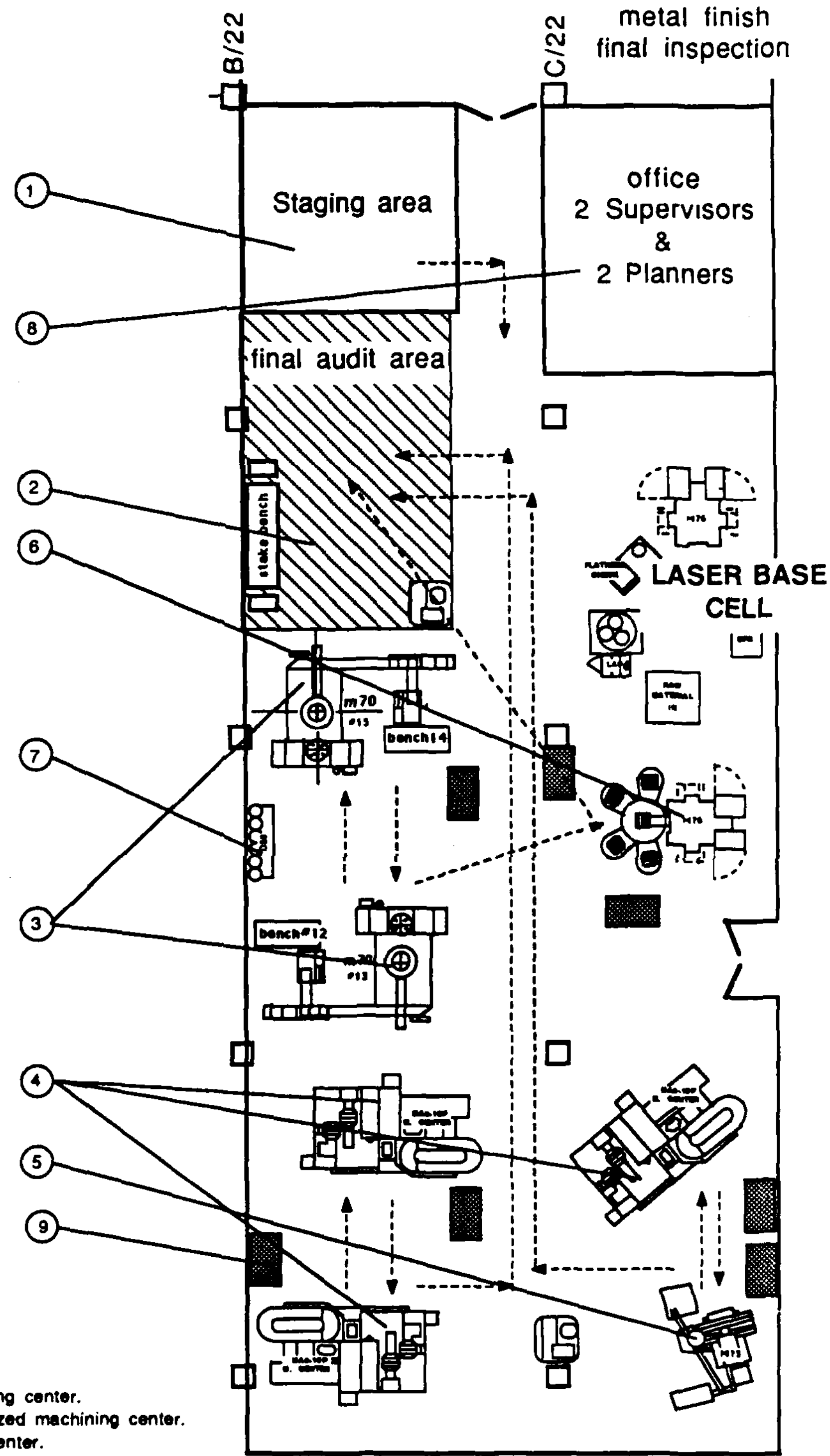
A built in probing system will measure and record all pertinent part dimensions that are accessible with a probe. For the remaining critical dimensions, the operator will gauge and check his work with a variety of inspection instruments. The gauges will have digital displays with electronic output going to a data collector. A predetermined lot size will be identified for Special Process Control (SPC), which the operator will check during the cycle time. The benefits derived from this are improved quality, reduced throughput time, reduced scrap/rework and reduced inspection cost. Using an in-process inspection program, defects are more readily detected and can be corrected in the early stages of the process. Refer to Project 43 for additional details.

INTANGIBLES

The project identifies a certain number of intangible benefits that are described as follows:

- In a dedicated cell, the amount of training required to support the cell is greatly reduced.
- The dedicated product requirements become well known to the operator.
- Engineering, Production Control and supervision support is reduced.
- The engineering support consists more of process refinement (tool monitoring system, adaptive control, etc) and less "fire fighting".

PALLET CELL
LAYOUT AND MATERIAL FLOW -- TO BE



1. Pallet Cell staging area.
2. Stake Bench operations.
3. Cincinnati model 720 machining center.
4. Tsugami model MA10P palletized machining center.
5. Bostomatic vertical milling center.
6. Kitamura machining center with/manual pallet shuttle.
7. Drill press.
8. Supervisor's and planner's for the pallet cell.
9. Work Benches (7) pics.

Figure 5.1 "To Be" Pallet Cell Layout and Material Flow

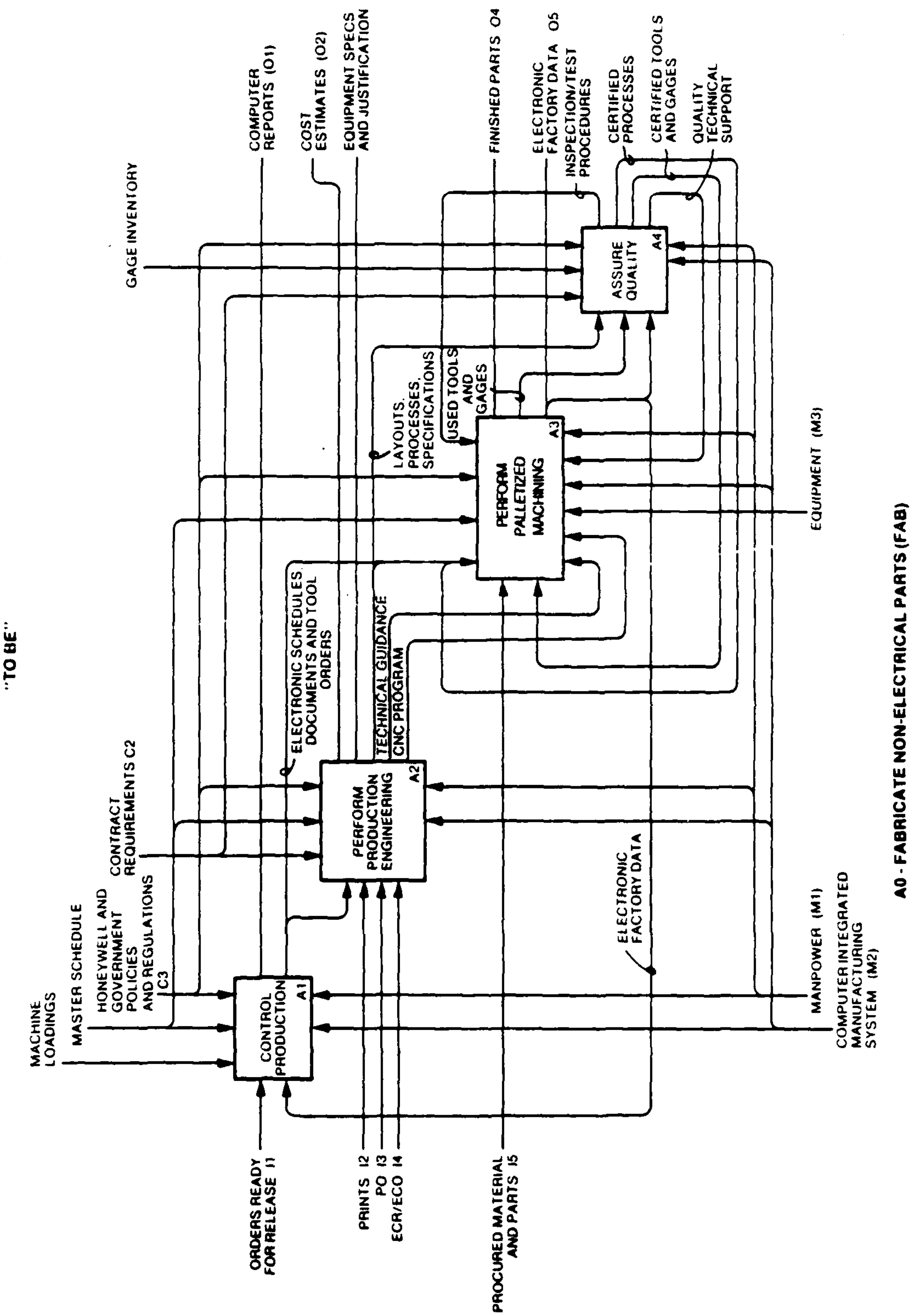


Figure 5.2 "To Be" Pallet Cell Workflow Diagram

SECTION 6

PROJECT ASSUMPTIONS

The following ground rules and assumptions were made in the analysis of the "Pallet Cell".

- The group technology concepts that were developed to fill the load for the Pallet Cell has to be followed when future parts are considered.
- A specific group of sub-contract parts will be reprocessed and brought in house.
- The capital and space will be made available to start the first stages of implementation in the third quarter of 1988.
- The "Pallet Cell" will be a phased implementation, starting in the third quarter of 1988 and an estimated completion in the fourth quarter of 1989.
- The floor space required for this cell will be made available when this phase of Project 44 is implemented.
- Labor classification changes in this portion of the project are not limited by the present bargaining unit contract.
- A one shift operation is based on 1700 operator hours per year with an estimated shop performance of 85%.

SECTION 7

GROUP TECHNOLOGY CODING SYSTEM ANALYSIS

The "Pallet Cell" is formed as a result of the Group Technology technique's used to identify all the potential cells that could be formed. This approach is identified in Section 3 of the Project Overview.

SECTION 8

PRELIMINARY/FINAL DESIGN AND FINDINGS

INTRODUCTION

The Pallet Cell consists of a combination of functional modules. These include palletized machining center, conveyor system, automatic chromate line, tool monitoring system, in-cycle gauging system, pallet shuttle table, distributive numerical control (DNC) link, coordinate measuring system and the two refurbished horizontal milling centers.

PRELIMINARY SYSTEM DEFINITION

The first step in developing the specifications for this manufacturing system was to define the part families that would be selected to run in this cell. The machining characteristics and the process operations were the key factors in the definition. Some of the parts require complex machining operations: for example, four orientations on the fixtures and some parts require thirty tools to complete all the machining operations. The variables within the part families (size, configuration, and commonality) determine the degree of flexibility, the machine requirements, tooling and fixturing.

The information on the part families was defined, collected and computerized into four areas.

1) Part material. Parts were selected from the aluminum family because of chip removal, cutting tools, tool geometry and coolant.

2) Tooling, subplates, riser blocks, cubes, and angle plates used in the current shop process. The machine tool interface with the individual fixtures (master locating devices) had to be economically convertible for use on a palletized machine to provide efficient set up of fixtures on the pallets.

3) Work piece fixtures. Fixture design had to include standard probing bushings or targets that could be verified during automatic loading into the machine.

4) Cutting tools. A total review of all the cutting tools for the family of parts was undertaken. Parts with common tools were selected to run on the same pieces of equipment.

A block matrix was prepared showing part family evaluations for each operation or orientation of a part: set-up time, run time, total quantity, lot sizes, number of tools per operation, part fixture costs (design, build) and programming. Upon completion of this matrix, a feasibility study was done on the various part families. The base elements for this study were annual load, volumes, product line similarities, tooling costs, lots per year and savings. Twenty eight different parts were selected from the Precision Control Instruments (PCI), Ring Laser Gyro (RLG), Commercial Aviation Division (CAvD) and Radar group of Flight Systems Operations (FSO) business groups. The projected orders for 1988 were selected as a base. These twenty eight parts selected had a total yearly machine time of 11,668 hours. This would fill the capacity of three machines for one year.

The equipment selected for this project was the Tsugami Lightning Model 10, with the Matsuura MC-400H the alternate choice. The Model 10 was chosen because of the pallet conveyor configuration and the pallet's vertical position to the spindle instead of the horizontal position of the MC-400H. The Tsugami Lightning Model 10, with its horizontal spindle, allows for easier chip removal. Both machines are competitive in price and offer the same features and options. The Model 10 has the capabilities of 126 tools. With the group of parts to be processed, having such a variation of tools is important.

CONVEYOR SYSTEM

Two types of conveyor systems were considered viable candidates for this cell. They were the "Power and Free" carrier system and the belt or roller style of conveyor.

The "Power and Free" system is an overhead mounted track with moving carriers suspended from load bars that are attached to trolleys. The carriers have the capability to accumulate or line switch at any point in the system without disrupting the flow of the other carriers in the system. The entire system has a computer based control that controls the destination and routing of the carriers.

The belt or roller conveyor is not an overhead system. Parts are transported along a flat belt to a centralized staging area where it waits for the next piece of equipment to become available.

The two systems were analyzed for technical feasibility. An economic analysis determined that this investment would not result in an acceptable internal rate of return. The decision was then made to plan to improve the material flow between work stations by using an automatic wire guided vehicle (AGV) system (ITM Project 21). Until Project 21 is implemented, stores personnel or the operators will move the parts to the next sequential operation.

AUTOMATIC CHROMATE LINE

In keeping with the flexible manufacturing concepts, an automatic chromate line seemed like a good step in keeping all the operations of these components in one localized area. A decision was made to do a study on the feasibility of installing an automatic machine to chromate the aluminum parts. It was assumed the machine would be located within 100 feet of the existing plating department and could share chemical storage, waste treatment, and supervision with the existing shop. Some potential problems, and the way they could be handled are listed:

1. Strong acids located close to machines.

   a) Castings would be purchased already pickled to eliminate two acids from the system.

2. Ventilation of the area.

   a. Two room temperature acids are needed in the chromate machine. System will be well ventilated, and the line would be enclosed to control air movement.

   b. A second exhaust system using an alternate source of power, would be installed to maintain a negative pressure at the machine if primary power fails.

3. A great variety of sizes and shapes of parts are involved which complicates the rinsing and draining.

   a. Universal rack is not deemed feasible, so a number of rack designs will be needed, some specific to individual parts and some specific to a general size and shape of parts. Racks will be hand loaded by an operator.

   b. Manual spray rinsing will be incorporated at some rinse stations.

4. Acids and chromate chemicals need to be regulated for sewer introduction.

   a. For chromate, a dragout rinse is included, and that rinse plus any batch dumps would be transferred by permanent pipe to the waste treatment area of the plating shop.

   b. Acids will be water jet aspirated through a permanent pipe to the same waste treatment area.

5. Two classes of chromate (1a and 3) are used on our parts.

   a. It is possible and quite common to draw both classes of chromate from the same process by using a proprietary chromate chemical that is approved for both classes.

The chromate line would be made up of 12 process tanks, a load station, an unload station and a dry station. The process tanks would be: one solvent degrease, one flash off, one alkaline clean, two acids, one chromate, five rinse and one hot deionized water spray. The rack transport would be by means of an automatic hoist traversing a straight line track in the method commonly used by the plating industry. The rack transport is computer controlled, with storage capability for eight process cycles.

It is projected that this chromate line will fit in an area 20 X 46 feet in size with the length and width of the machine, including load, dry and unload stations, dictating the shape of the area. It is further projected that the optimum arrangement would have a dry station off of the automatic machine, with a means of transporting racks to a separate conveyorized dry unit that moves racks to an unload station and permits some stacking of racks.

These concepts have been discussed and will be investigated in detail when the proposed cell has been installed. The benefits derived from this system would mean additional reductions in labor costs and improvements in material flow.

An extensive investigation was done on a cost analysis to determine if such an automated system could be justified. With the current volumes of the selected parts in this cell, a good return could not be accomplished. A decision was made to use the existing Metal Finish Department chromate area for finishing these parts. The parts could still be shuttled between work centers by means of stores personnel or the automatic wire guided vehicle (AGV) system that is planned for in Project 21. If the part volumes increase, this concept would be a viable addition to this cell. With the proposed "To-Be" layout, this chromate line would easily be incorporated into the Sheetmetal Cell and the Pallet Cell in the future.

TOOL MONITORING SYSTEM

With the degree of automation that exists in this Pallet Cell, a need for a tool condition monitoring system was necessary to support this complex, high cost, manufacturing cell. This type of system is designed to measure the slightest change in a tools load. Each cut of each tool is compared to a set of programmed limits. When the tool reaches these load limits, within milliseconds, a signal is sent to shut down the feed drive. With this rapid detection of tool wear, tool breakage and collision, the operator is alerted to any problem in the system. The advantages of a continuous monitoring system are: reduced down time, machine operators are no longer overburdened, maximum utilization of machines, and reduction of tool breakage causing increased tool costs and reset costs. The implementation of this system will be phased in after the DNC machining centers are up and running.

IN-CYCLE GAUGING

In-cycle gauging gives the machining centers the ability to perform part inspection and fixture and pallet positioning within the cycle of the machine. Using touch probes, it is possible to perform gauging operations on the machine tool. Probing macro's are loaded into the DNC's memory and recalled by the NC programmer with a simple G code. Offsets in the control system can be updated, and quality control maintained without manual intervention. With the degree of complexity in the parts that are being run in these centers, this control system is included as an option. This concept offers a variety of cost saving and quality control techniques.

REFURBISHING OF HORIZONTAL MACHINING CENTERS

A selected group of parts are being dedicated to two of the machines in this cell (Cincinnati model 720). Instead of making the investment of two new horizontal machining centers to support this group of parts, a decision was made to refurbish the existing equipment. This refurbishing will be done by the manufacturer, and will include new servo motors, spindle motor, coolant pump, table modification, replacement of the bearings, feed rate upgrade and a upgrade of the CNC to DNC controls.

PALLET SHUTTLE TABLE

One designated machine from this cell (Kitamura Mycenter 2), will be dedicated to run a group of parts that require a secondary operation. To be able to save the set-up time from the secondary operations and to increase the cutting time of the machine, a modular off the shelf shuttle device is necessary. This device directly attaches to the machine and allows the operator to set up for secondary operations while the primary operations are being performed. The only time lost in this operation will be the load/unload of the parts. In this concept, the advantages of such a shuttle system are its simplicity, and the drastic reduction of set-up times.

DISTRIBUTIVE NUMERICAL CONTROL LINK

The Distributive Numerical Control (DNC) programming system will be on-line with the cell's machining center's. All operator and engineering changes, program updates and modifications will take place from the programming center. The digitized information will be transferred via a hard wired RS-232 connection. Active programming data will be stored on a hard disk which can be directly down loaded to the machining centers. This allows complete flexibility in part programming.

COORDINATE MEASURING SYSTEM

There are two categories of dimensions in a part that have to be inspected. The first category is continuously being checked in the machine by the probing system described above. These dimensions are considered critical and directly related to the function of the components. The second category of dimensions are non-critical but are important as far as the final configuration of the part. Therefore, they need to be checked after machining. To accomplish this, the acquiring of two coordinate measuring systems are necessary to automate this task. The details of this system are included in Project 43 report.

CELL SIMULATION

All current cutting tools, fixtures, standard mounting plates and process notes were matrixed for parts considered for the cell. The same information for the proposed process was again matrixed. Analysis of the machine usage patterns allowed selection of machines with fewer tool holders, thus allowing assignment of smaller parts families to each machine. This resulted in reduced capital, tooling, and machine cycle (tool change) costs for all the equipment in the cell. Equipment venders offer field installation for additional tool carriers if future events call for an increase in tool holder requirements on the horizontal pallet machining centers.

Labor standards were developed for the "To-Be" machining processes. They were developed from: time study inputs of the same part by two or more machine vendors; metal cutting cycles developed from published Met Cut Machining data; and current actual time studies and modified (with I.E. concurrence) current standard labor calculation sheets. These inputs, modified by a six month rolling average of labor performance, were combined with best engineering judgement for projected actual labor per operation. The twenty eight selected parts, including four currently subcontracted, will fully utilize the cells capacity. Additional parts, of borderline volume for inclusion were identified as replacement cell population members if the volumes of primary parts decline. If primary part volume increases load leveling alternatives were the subcontracting of the previously subcontracted parts or resourcing the parts, with their current documented processes, to the Flexible Machining Area or Short Run Shop. The capabilities of the Capacity Requirements Planning module of HMS were reviewed. The system was determined to have the proper planning tools to balance the cell workload on both a short term and long range basis.

CELL LAYOUT AND WORK FLOW

Raw material, castings or rough saw metal plate stock, is moved by stores personnel from the stock area near the loading docks to the cell staging area (reference Figure 8.1). Long range and daily CRP (capacity requirements planning) runs assign job priorities. Deviations to this schedule are made by Production Control and the cell Supervisor to meet an overall schedule and interface with other manufacturing resources. When directed by supervision, the raw material is manually transported to the selected machines by a group leader. The selected machine or machine combination completes all pre-metal finish machining.

The pallet machines have specific parts of operations constantly set up and stored on vertical conveyor pallet holders controlled by machine sensors. One part can be sequentially run through all operations as controlled by the machine control sensor. Several parts can be sequentially run on the machine. An order of one part is as cost effective as a run of 500.

The non-palletized horizontal machining centers are set up for specific long range orders. One operator runs two machines and related chore machines or tasks during machine run time. Certain secondary operations are completed on vertical machining centers within this cell.

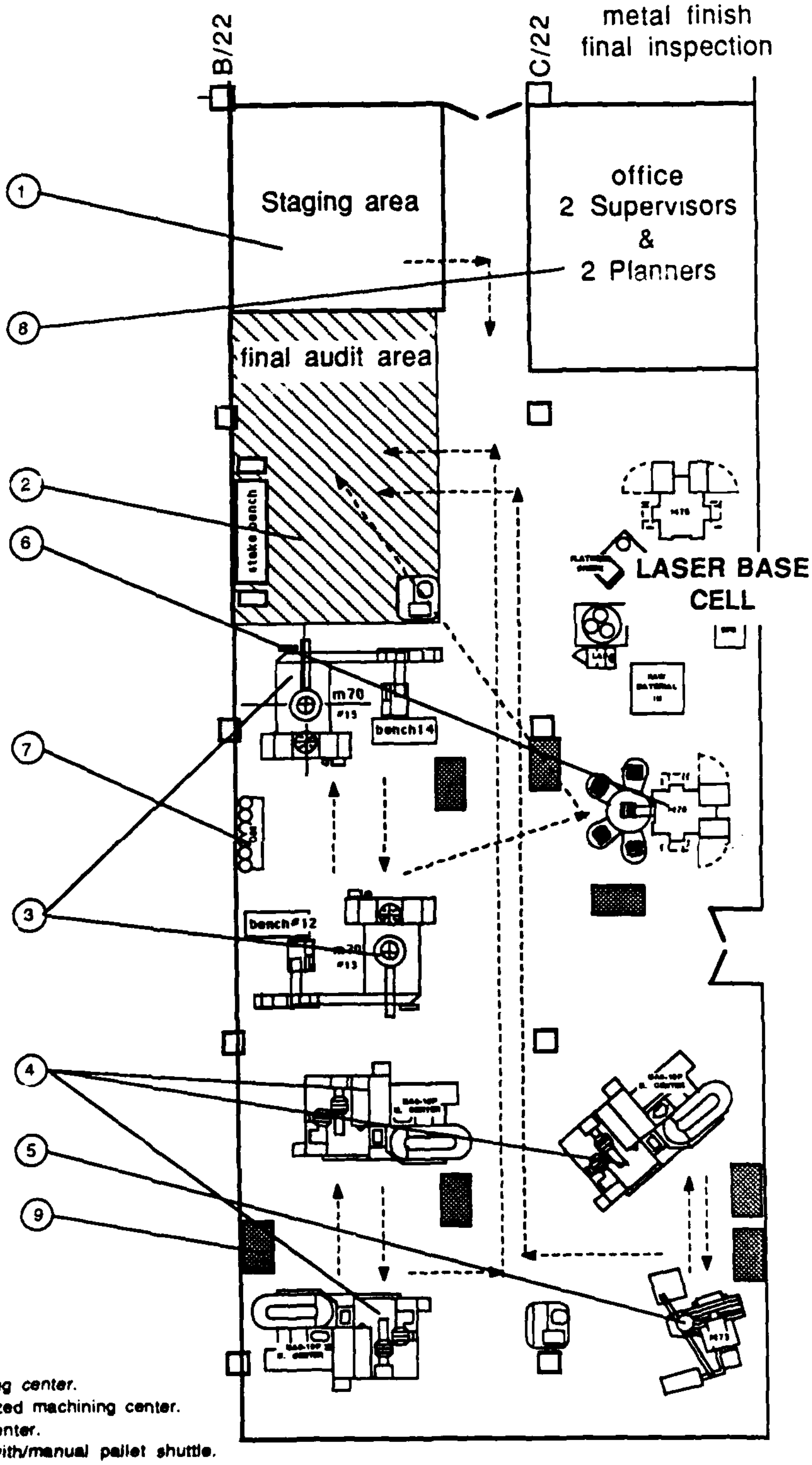
A vertical machining center, equipped with a pallet exchange system and stored preset tools, completes specific selected secondary operations from the horizontal non-pallet machine and the post metal finish operations. Complete changeover between jobs is accomplished in less than five minutes. The group leader stages all set-up changeover requirements for the machine prior to the delivery of parts to the machine.

After acceptance by inspection, parts are moved to the Metal Finish staging area next to the cell staging area. The Metal Finish Production Control representative and Supervisor, co-located in the same office as their Pallet Cell counterparts, schedule and complete surface treatments.

The parts are assessed in the Metal Finish inspection area. Completed parts are sent to stock or assembly lines. Parts requiring post metal finish machining or stake bench operations are returned to the Pallet Cell staging area for completion.

When the post metal finish and inspection operations are completed, the parts are moved to the staging/stake bench area. All tools and fixtures for cell jobs are kept set up. Most heli-coils and stake nut installation, and assembly of components is done as a single operation. Parts are inspected and moved to stock or product lines as directed by HMS routings.

PALLET CELL
LAYOUT AND MATERIAL FLOW -- TO BE



1. Pallet Cell staging area.
2. Stake Bench operations.
3. Cincinnati model 720 machining center.
4. Tsugami model MA10P palletized machining center.
5. Bostomatic vertical milling center.
6. Kitamura machining center with/manual pallet shuttle.
7. Drill press.
8. Supervisor's and planner's for the pallet cell.
9. Work Benches (7) pcs.

Figure 8.1 "To-Be" Pallet Cell Layout and Material Flow

SECTION 9

SYSTEM/EQUIPMENT/MACHINING SPECIFICATIONS

EQUIPMENT IDENTIFICATION

The "Pallet Cell" will consist of and be supported by the following equipment:

1. CNC machining center (Tsugami model MA3-10P; 3 each)

   - Automatic pallet changer with 10 pallet magazine.
   - Horizontal spindle.
   - Four axis machining capabilities.
   - 126 tool magazine.
   - Funuc or compatible control.
   - DNC interface with RS-232 port.
   - 6000 rpm spindle speed.
   - BT40 tooling system.
   - Table travel of 12" x 12" x 12".
   - 10 horsepower spindle motor rating.

2. CNC machining center (Cincinnati model 720, current property of Honeywell Inc.; 2 each)

   - Axis travel of 24" x 15" x 20".
   - Horizontal spindle.
   - 24 tool capacity.
   - DNC interface with RS-232 port.
   - Funuc or compatible control.
   - Four axis machining capabilities.
   - 10 horsepower spindle motor rating.
   - 3500 rpm spindle speed.

3. CNC vertical machining center (Kitamura Mycenter-2, current property of Honeywell Inc.; 1 each)

   - 10,000 rpm spindle speed.
   - 16 tool storage capacity.
   - 80 meter tape storage (262 feet).
   - Funuc 11 MA with 14" CRT.
   - Machine dimensions 106" x 73".
   - 7.5 horsepower spindle motor rating.
   - DNC interface

4. CNC vertical machining center (Bostomatic model 312, current property of Honeywell Inc.; 1 each)

   - Four axis machining capabilities.
   - DNC interface with RS-232 port.
   - 12 tool capacity.
   - Bostomatic SPC II control.
   - Table size of 12" x 44".

5. Manual pallet changer system. (1 each)

   - Minimum pallet size 12" x 12".
   - Repeated positioning accuracy of the pallet of .0004 inch.
   - Five pallet capacity.
   - Load capacity of 500 pounds.
   - T slotted pallets.
   - Adjustable height.

6. Tool condition monitoring system. (3 each)

   - Able to monitor 99 tools.
   - Capable of 100 cuts per tool.
   - Interface with host computer.
   - Able to monitor tool wear and tool breakage.
   - Capable of monitoring small depths of cut in aluminum.
   - Spindle horsepower monitoring.
   - Feed force monitoring.

7. In-cycle gauging system. (3 each)

   - Probes locate in a tool position.
   - Interface with a Funuc control.
   - Capability to interface with a host computer.
   - Ability to preset registers (G92).
   - Identify hole locations and measure diameters.
   - Locate surfaces.
   - Automatic recording of dimensions through a DNC system.
   - Probes can be invoked by G code.

SECTION 10

TOOLING SPECIFICATIONS

INTRODUCTION

To be able to analyze the tooling requirements for the "Pallet Cell", a breakdown of each job into its individual components was necessary. These components were cutting tools, tool holders, tooling, fixturing, plates and subplates.

CUTTING TOOLS

All the cutting tools used in this application are considered perishable. They will be procured as a standard item from an outside vendor source and discarded when all cutting edges are worn. These cutting tools will be adapted to the machining centers using the existing tooling system in place. Figure 10.1 represents how this tooling interfaces with the machining centers. The geometry and material of the cutting tools will be determined by the production engineering group. The tooling will be controlled in a central tool crib and dispensed upon demand. The tool crib will monitor a minimum/maximum stock based on shop usage.

TOOL HOLDERS

A BT35, BT40, BT45 tool holding system was identified to support this cell. These tool holders are off the shelf items and will be procured from a supplier and integrated in the cell on an as needed basis. Figure 10.2 represents the systems required to support these tooling requirements.

TOOLING AND FIXTURING

The tooling and fixturing required to support this cell currently exists in Fab Fac production. Slight modifications in the construction and design are necessary to adapt this tooling and fixturing to the riser blocks, angle plates, and cubes that are to be used. These modifications would include re-location of locating pins and bolt holes for quick fixture changing. Any new fixture concepts will require the production engineer to work with the tool designer to pass on the tooling concepts and specifications defined by this project. This process will involve creating or revising the tooling prints, reviewing designs, monitoring fabrication, and try-out through production.

PALLET FIXTURES, PLATES, SUBPLATES

The master tooling, subplates, riser blocks, cubes and angle plates that are required to support the individual fixtures for this cell are identified in Figure 10.3. These components are available from suppliers as off the shelf items. The production engineering department will coordinate the procurement, modification, and implementation of these items into the cell.

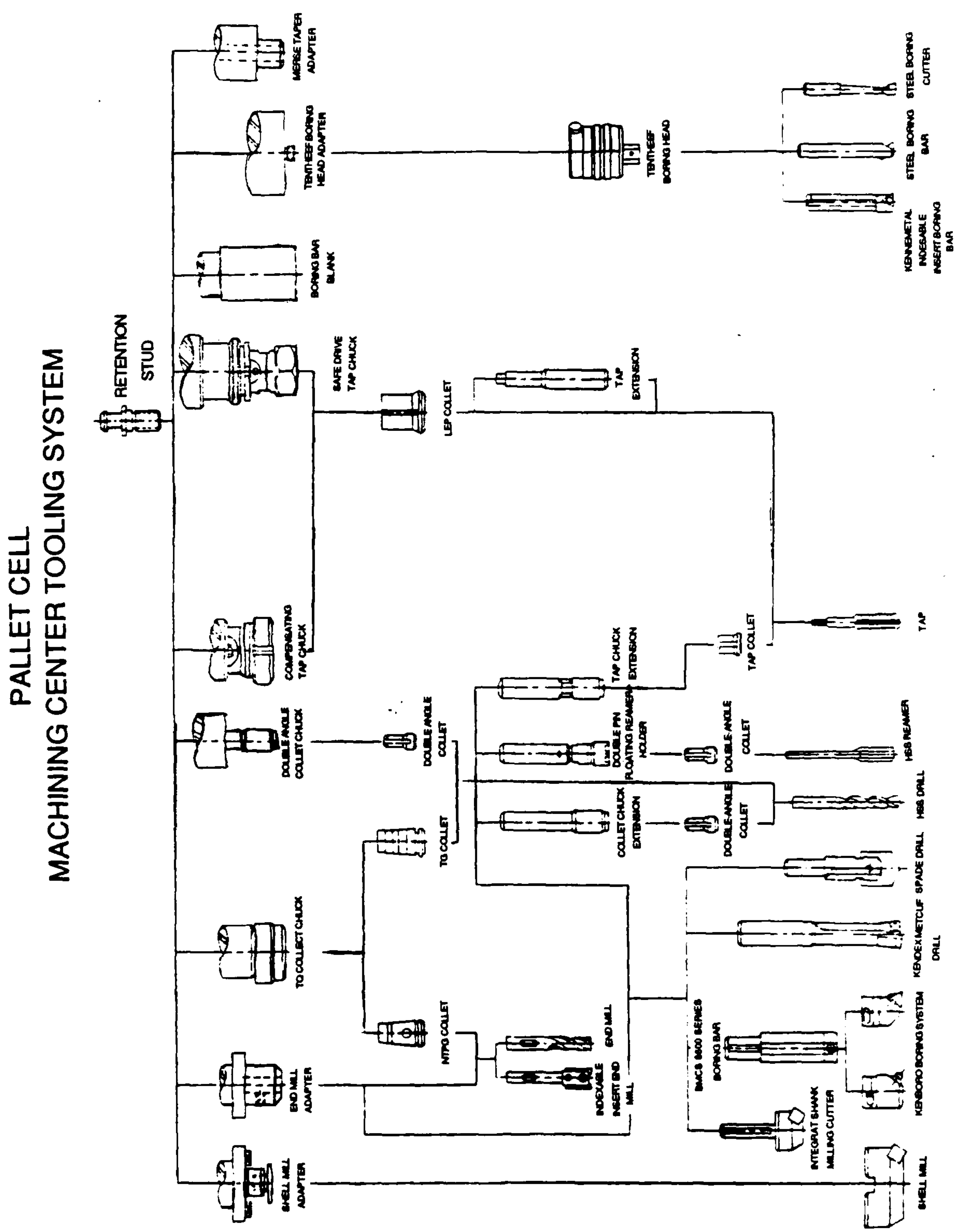
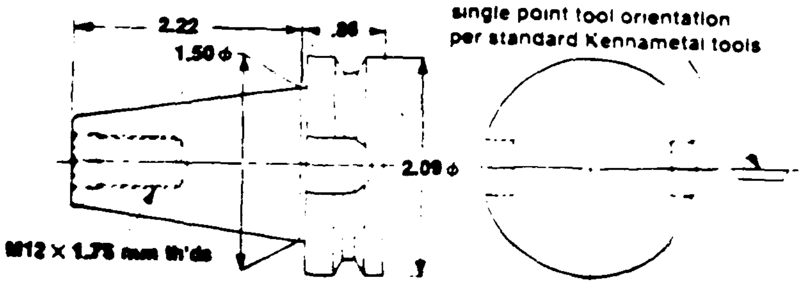


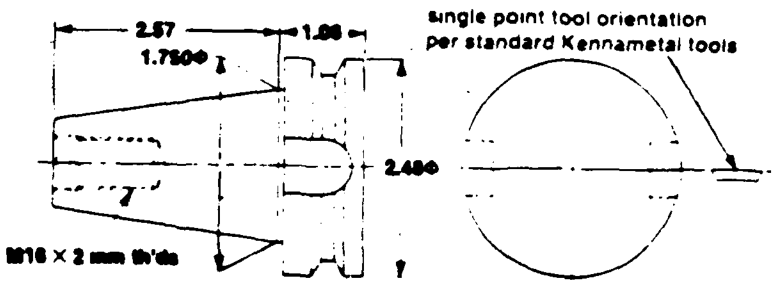
Figure 10.1 Machining Center Tooling System

PALLET CELL
TOOL HOLDERS

BT-35 Tooling



BT-40 Tooling



BT-45 Tooling

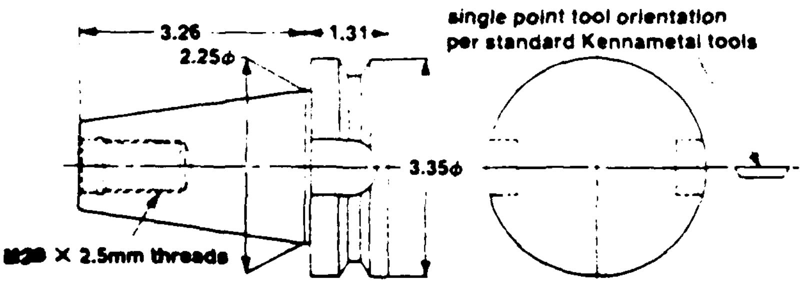
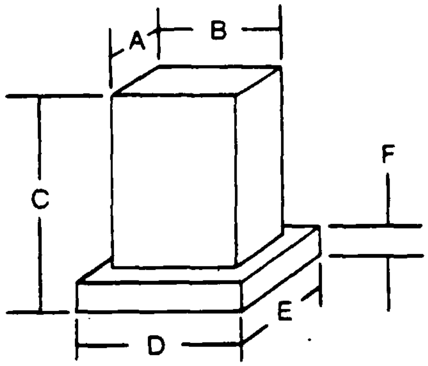
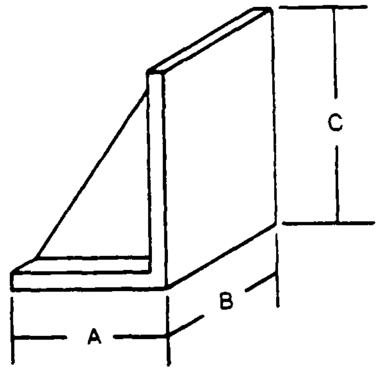


Figure 10.2 Tool Holders



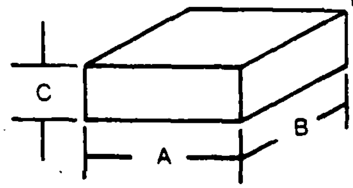


TOMBSTONE

Model Nos.	A	B	C	D	E	F
MS9922	9	9	22	16	16	1.7
MS91522	9	15	22	21	16	1.7
MS92032	9	20	32	24	17	2.2
MS121224	12	12	24	18	18	1.7
MS141426	14	14	26	25	25	1.7
MS181830	18	18	30	22	22	2
MS242436	24	24	36	28	28	2.2

ANGLE PLATE

Model Nos.	A	B	C
MS121212	12	12	12
MS181818	18	18	18
MS242424	24	24	24
MS181836	18	18	36
MS182436	18	24	36
MS183036	18	30	36
MS182448	18	24	48
MS242448	24	24	48



RISER / TOOLING BLOCK

Model Nos.	A	B	C	Model Nos.	A	B	C
MS14144	14	14	4	MS22224	22	22	4
MS14145	14	14	5	MS22225	22	22	5
MS14146	14	14	6	MS22226	22	22	6
MS14147	14	14	7	MS22227	22	22	7
MS16164	16	16	4	MS24244	24	24	4
MS16165	16	16	5	MS24245	24	24	5
MS16166	16	16	6	MS24246	24	24	6
MS16167	16	16	7	MS24247	24	24	7
MS18184	18	18	4	MS30304	30	30	4
MS18185	18	18	5	MS30305	30	30	5
MS18186	18	18	6	MS30306	30	30	6
MS18187	18	18	7	MS30307	30	30	7
MS20204	20	20	4	MS32324	32	32	4
MS20205	20	20	5	MS32325	32	32	5
MS20206	20	20	6	MS32326	32	32	6
MS20207	20	20	7	MS32327	32	32	7

Figure 10.3 Pallet Fixtures, Angle Plates, Riser Blocks

SECTION 11

VENDOR/INDUSTRY ANALYSIS/FINDINGS

An industry survey was conducted to identify the companies that are capable of supplying the following items to meet the requirements of the "Pallet Cell".

1. CNC Machining center.
2. Cincinnati Milacron model 720 refurbishing.
3. In-cycle gauging.
4. Tool monitoring system.

SELECTION CRITERIA

An industry search was conducted to identify the companies that would be capable equipment suppliers/integrators. In view of the many ongoing advances in machine tool automation and metal removal technology, we tend to think of modern mechanical manufacturing (CNC Computer Numerical Control) as a highly productive and efficient process. The information for preparing this evaluation was obtained by:

- Conducting an extensive literature search (local and foreign), of the Thomas Register, technical journals, advertisements, etc.

- Contacting suppliers.

- Contacting several suppliers of the machines and visiting a few of them.

In order to obtain detailed information, part drawings, and in some cases sample parts were prepared and sent to selected companies to ensure capabilities and time estimates.

After review and assessment of the companies active in the market, several vendors were selected based on the following criteria:

- Capability to deliver.
- Servicing and training support.
- Machine requirements and capabilities.
- Project support in supplying pertinent data.
- Size and financial stability (as indicated by Dunn & Bradstreet reports).

Although tool cost, which reflects both the price of the equipment and its durability, is important, it is not necessarily the ultimate criteria. What is important, depending on objectives, is either minimum total cost of the machining operation or maximum production rate. Equipment utilization is very high because everything necessary to produce the parts are in one location while one operator runs multiple machines in the cell for optimum productivity.

EVALUATION CRITERIA

Six potential suppliers were selected to bid on the proposed project. They included:

- Concept Mach. Minneapolis. - Representing Tsugami Ltd.
- Productivity Inc. Minneapolis. - Representing Matsuura Ltd.
- Granquist Company Minneapolis. - Representing Kitamura
- Anderson Machine Tool Minneapolis. - Representing Hitachi/Seiki
- Kearney & Trecker Corp.
- Cincinnati Milacron

The vendors were supplied with part prints and generic equipment requirements. They were required to give time estimates, detail equipment specifications and current price quotes on the information supplied to them. Following the receipt of the quotes and data, an equipment file was prepared for each piece of equipment.

SELECTION CRITERIA

The selection criteria for potential equipment suppliers consisted of several levels of response and evaluation. They were also directed to be completely responsive to the specification, itemizing exceptions or alternatives proposed. Price for the equipment certainly would be a key evaluation point, but not the only one. It was asked that these vendors give time estimates, equipment and required accessory costs for evaluation. As a result, the following equipment and vendor was chosen.

- Concept Machine Tool Sales - Tsugami Model 10 Lightning MA-3H

  This machine is a sophisticated horizontal machining center. It was selected because the equipment incorporates some of the most advanced engineering features and innovations available today. These features, combined with optionally available automated peripherals such as automatic gauging, robot loading, tool life management, etc., will provide a complete production system from raw material to completed product with a minimum of operator attendance. The accuracy of this machine as well as the capacity and speed are of great importance.

SECTION 12

EQUIPMENT ALTERNATIVES

If the Tsugami Model 10 becomes unavailable, the Matsuura Model 400H would be selected. This machine was selected as an alternative because of its high performance, accuracy and similarity in tooling and programming. The equipment performance is comparable to Tsugami Lightning Model MA-3H. However, the equipment has a vertical spindle and only a 62 tool capacity.

SECTION 13

MIS REQUIREMENTS/IMPROVEMENTS

The "Pallet Cell" interfaces with Honeywell Manufacturing System (HMS), Process Management System (PMS), and Factory Data Collection (FDC) without modification to other systems hardware or software. These elements are discussed in further depth in Section 13 of the Project Overview.

Specific part dimensions will be captured by a Statistical Process Control (SPC) system within each cell. Complete details of SPC are covered in the Project 43 report.

SECTION 14

COST BENEFIT ANALYSIS/PROCEDURE

OVERVIEW

The Pallet Cell is a dedicated cell that will produce 28 different machined parts. The combination of these parts support a wide variety of Honeywell's production lines, ranging from inertial components to ring laser gyroscopes to commercial navigational devices.

Reduction in actual standard hours was identified as a tangible cost driver, through the methodology shown in the process diagram of Figure 14.1.

MANUFACTURING SCHEDULE

The analysis and development of the manufacturing schedule for the Pallet Cell was generated on a part by part basis. Two different methods were used, depending on availability of data. For the majority of the parts used the current year's volume (number of piece parts) was used and the volumes escalated by the percent change of the corresponding operation's revenue plan projections for the out years. The remainder of the parts used the marketing plan volume projections by product device.

ACTUAL STANDARD HOUR SAVINGS

The methodology for deriving the "As-Is" and "To-Be" actual standard hours and sub-contract versus in-house manufacturing was followed as described in Section 14 of the Project Overview.

In addition to standard hour reduction, the Pallet Cell analysis also addresses two additional areas where tangible savings will be realized. These include reduction in set-up time and an efficiency improvement due to the introduction of in-cycle gauging. The set-up reduction is a result of the palletized fixturing system and dedicated, pre-set tooling on the new CNC machines, which will eliminate major portions of mounting and tearing down of fixtures and tools. The in-cycle gauging was determined to increase cell productivity by 3%. This analysis was based on a conservative engineering judgement and outside vendor recommendations.

CAPITAL AND EXPENSE

The capital, recurring and non-recurring expense for the Pallet Cell is shown in Figure 14.2.

PROJECT SAVINGS AND CASH FLOWS

The savings to be realized by this cell exceed Honeywell's Military Avionics Division hurdle rate. The cell's cash flows are shown in Figure 14.3 with the assumption that capital is available per the implementation plan.

COST BENEFIT ANALYSIS METHODOLOGY

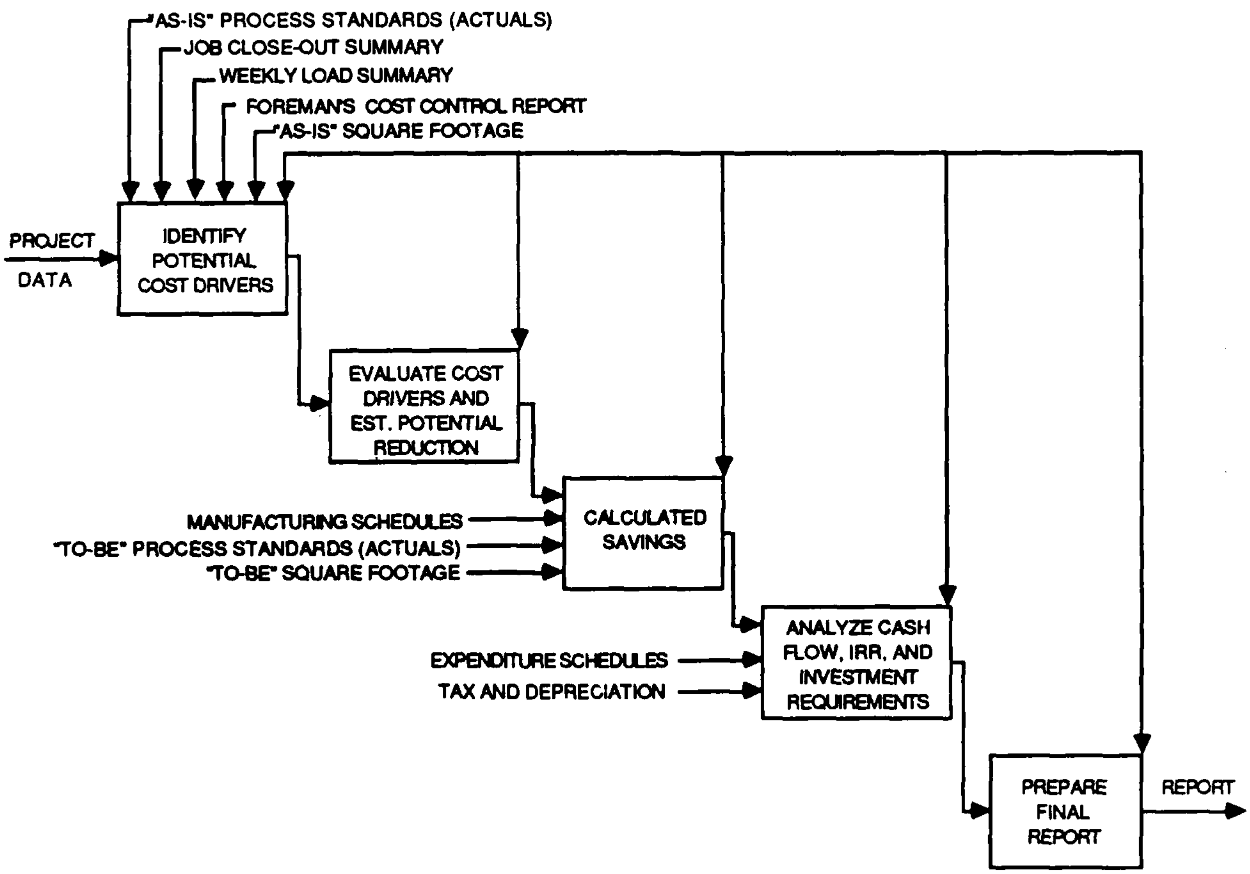


Figure 14.1 Pallet Cell Cost Benefit Analysis Methodology

PALLET CELL
EXPENDITURE SCHEDULE

	Cost	Capitalization Date
CAPITAL COSTS		
MACHINERY COSTS		
** CNC Machining Centers (2)	$785,094	1988
** CNC Machining Centers (1)	$392,547	1989
** Tool Monitoring System (3)	$132,635	1989
** In-Cycle Gauging (3)	$68,327	1989
** Pallet Shuttle Table	$46,891	1989
** CNC Machining Center Refurb. (2)	$334,938	1989
** Area Preparation (Material)	$6,029	1988
** Tooling (HI)	$22,158	1988
** Tooling (Purchased)	$151,558	1988
** Tooling (HI)	$22,279	1989
** Tooling (Purchased)	$80,100	1989
	$964,839	1988
	$1,077,717	1989

TOTAL MACHINERY COSTS	$2,042,555	
FURNITURE COSTS		
** N/C Tool Storage Cabinet	$6,431	1989

TOTAL FURNITURE COSTS	$6,431	1989
	$964,839	1988
	$1,084,147	1989

TOTAL CAPITAL COSTS	$2,048,986	

	Cost	Year Expended
EXPENSE COSTS		
NON-RECURRING EXPENSES		
Area Preparation Labor (HI)	$67,200	1988
Training (HI)	$6,000	1988
Process Development Direct Labor	$75,500	1988
Post Processor Development Direct Labor	$8,000	1989
	$148,700	1988
	$8,000	1989

TOTAL NON-RECURRING COSTS	$156,700	

TOTAL CAPITAL + NON-RECURRING	$2,205,686	
RECURRING EXPENSES		
* Annual Maintenance (Mechanical)	$4,500	
* Annual Maintenance (Computer HW)	$1,165	
* Annual Maintenance (Computer SW)	$583	

TOTAL RECURRING	$6,248	

* Expense starts in year 2.

** Costs contain a 15% contingency

Figure 14.2 Pallet Cell Expenditure Schedule

TECH MOD PHASE 2

PROJECT 44 -- PALLET CELL

PROJECT CASH FLOW SUMMARY
($000)

	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	TOTAL
Capital	$964.8	$1,084.1	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	$2,049.0
Non-Recurring Expenses	$148.7	$8.0	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	$0.0	$156.7
Recurring Expenses	$0.0	$0.0	$2.9	$6.2	$6.2	$6.2	$6:2	$6.2	$6.2	$6.2	$6.2	$6.2	$59.2
Total Savings	$0.0	$425.3	$677.5	$785.7	$939.0	$1,127.1	$1,342.3	$1,647.4	$2,043.7	$2,482.5	$2,993.2	$2,078.2	$16,541.8
Depreciation	$96.5	$281.7	$333.5	$266.9	$213.6	$171.0	$136.9	$129.1	$138.2	$138.2	$105.7	$37.7	$2,049.0

Figure 14.3 Pallet Cell Cash Flows

SECTION 15

IMPLEMENTATION PLAN

OVERALL IMPLEMENTATION PLAN

The implementation plan describes all the activities required to prepare the factory for the installation of the "Pallet Cell". Figure 15.1 shows all phases of the plan. The key elements driving this plan are described below.

BUILDING PREPARATION

Plant Engineering will prepare the plans for the construction of the area where the Pallet Cell will be located. This will involve the relocation of power, air, ventilation and the rearrangement of the machining centers and miscellaneous equipment.

ENGINEERING

Production Engineering will develop the processes and methods for the parts dedicated to this cell. This includes preparing the detailed instructions, tools, submittal of the tool requests and providing assistance in the ordering of capital equipment.

TOOLING AND FIXTURING

All new and modified fixtures will be processed through the tool design department and followed by the production engineering group. The tooling for the applicable parts will follow a procedure consisting of a design stage, design approval, build and tryout prior to a production run of the parts.

CAPITAL EQUIPMENT

A Production Engineer will be selected to integrate and follow up on the elements of the implementation schedule. The procurement, receiving, installation and the training of personnel will be coordinated through this individual.

HARDWARE

Based on the system requirements, orders will be placed for the procurement of the hardware involved in a Distributive Numerical Control (DNC) link. Upon receipt of the hardware, the mechanical and electrical installation will be handled by the supplier and internal support personnel.

SOFTWARE

The Distributive Numerical Control (DNC) link connects a group of numerically controlled machines to a common computer that stores various part programs. To implement this phase of the cell, a post-processor has to be developed for these controls to communicate with each other. This operating software will be developed and implemented through the Production Engineering group as part of this project.

PALLET CELL
IMPLEMENTATION SCHEDULE

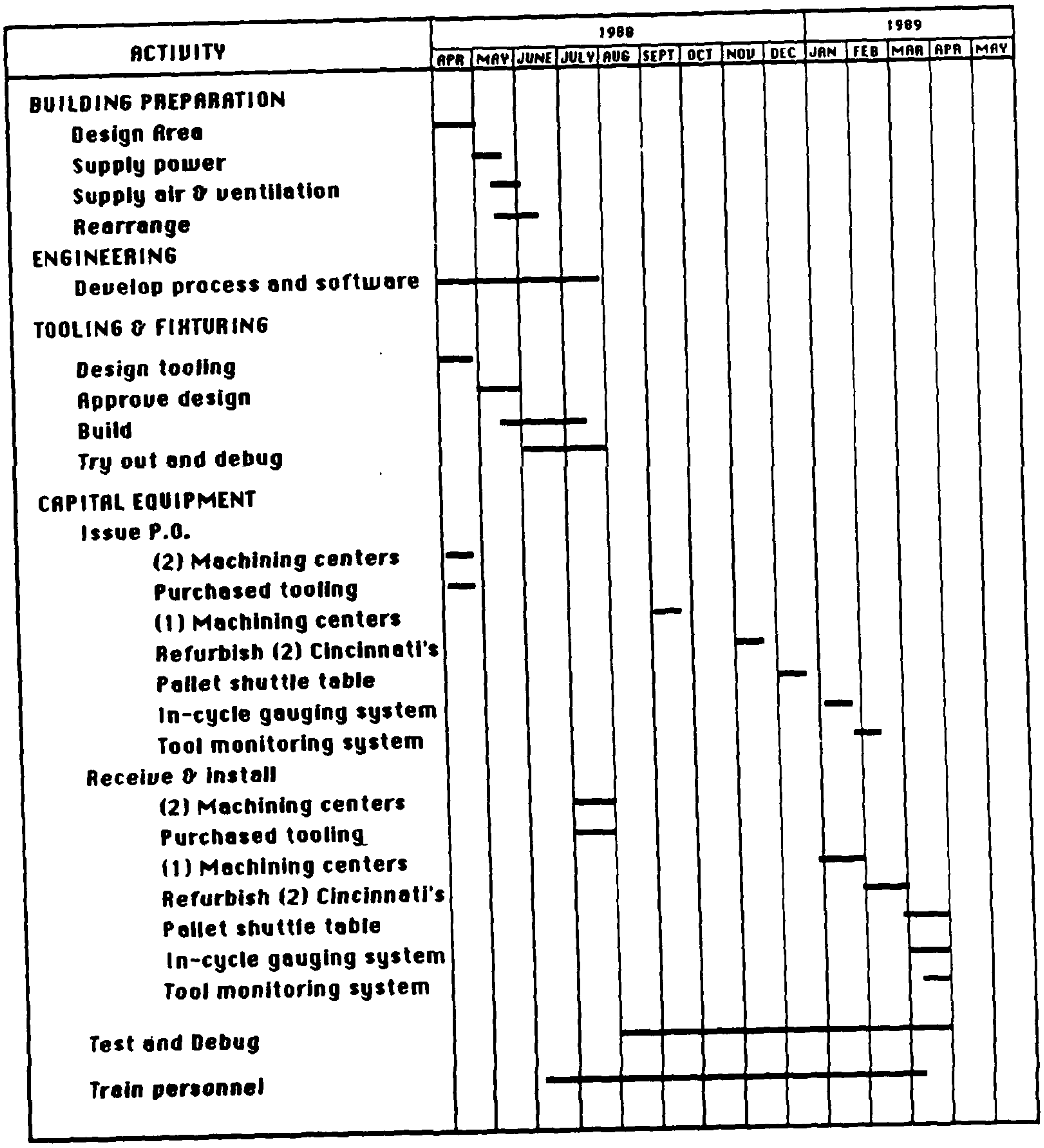


Figure 15.1 Pallet Cell Implementation Plan

SECTION 16

PROBLEMS ENCOUNTERED AND HOW RESOLVED

EXCESSIVE INSPECTION AND GAUGING

In the proposed "To-Be" process, the production operator will check his parts according to the Quality instructions on the detail instruction sheets. The operator will then record the data and it will be uploaded to a mainframe computer. The parts selected for this cell also require complex inspection and gauging. This creates a condition, where the operator, assigned to these machining centers will be overburdened with an increased amount of inspection work.

RESOLUTION

A need for an in-cycle gauging system was identified to resolve this problem. This system will give the machining centers the ability to perform part inspection parallel with the cycle time of the machine.

SECTION 17

AREAS FOR FUTURE CONCERNS/DEVELOPMENT

FUTURE CONCERNS

Forecast Volumes

The equipment utilization and return on investment are based on the current projected volumes. If the volumes on this group of parts decrease, a secondary set of parts would have to be identified. The entire context of this cell would have to be rescoped.

FUTURE DEVELOPMENTS

Automated Chromate Line

A percentage of the parts run in this cell require a chromate finish. To keep this portion of the process in a single segregated area, an Automatic Chromate Line would be a necessary improvement to control the material flow and material handling. With the current volumes of the selected parts in this cell, a good return could not be accomplished. If the volumes for these selected parts increase, reconsideration will be given to implement this concept into a cellular approach.

Automatic Wire Guided Vehicle

All the material handling in the Pallet Cell will be performed manually or with manual handling equipment. Tech Mod Project 21 would automate the inter-area material handling between stores, the stake bench, chromate area and the machining centers. Space has been provided to accommodate the implementation of such a project. The benefits in this system are reduction in labor costs and improvements in material control and lead times.